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Volume XV, Number 2 April, 1961

PRINTED BY COLUMBIA UNIVERSITY PRESS, NEW YORK, N.Y.

Traffic Quarterly

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Published quarterly by the Eno Foundation for Highway Traffic Control, Inc., at Saugatuck, Connecticut, issue for April 1961. Printed in the U.S.A. Library of Congress catalog card: 50–1781.

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Driving

Automotive transportation is the keystone to our high standard of living. Notwithstanding our system of licensing and driver supervision, we have an unenviable record of destruction of life and property. This record is becoming a matter of grave concern to the driving public.

Ordinary observations of public driving are convincing that control measures in this area are ineffective and incompatible with other efforts of maintaining safety and public order.

In 1958 we had 81,536,726 car, truck and bus licensed drivers in the country; officially qualified and licensed to drive—but, just as obviously, many are not. If they are properly qualified but do not drive accordingly, we must assume that they have disqualifying characteristics such as judgment, temperament, constitutional timidity, bravado, or ineptitude.

Except in the most obvious case, these possibilities receive only passing consideration, but may in the future require unfortunate and more serious attention. At present, little is known of their direct contribution to our high accident rates.

Manipulation of the car is an important part, but *only* a part, of driver qualification. Proper driving attitude and attention are essentials of good driving. Unexpected situations require a high state of mental composure to assure appropriate driver reaction, generally described as driver aptitude. All drivers do not have it.

There are some shortcomings in our driver-licensing system. It is possible to increase the thoroughness of qualifying drivers by including other qualifications essential to good driving. It would tend to impress the new driver with a greater sense of seriousness and appreciation. We are concerned, as we should be, with speed and intemperance, but we should no longer ignore other attributes of poor driving.

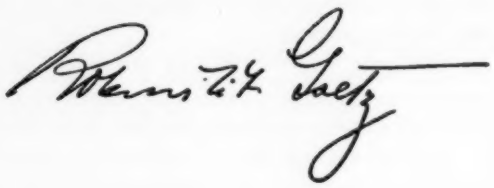
Careless, needless or inept driving is an indisputable indication of the absence of qualifications. Any of these should be, on first occasion, sufficient cause for cancellation of a driver's permit.

If we are determined to improve our driving, it is folly to pursue

our present attitude toward licensing. The driving public should be aroused to more significant deterrent measures.

We need a war-cry or slogan to curtail our lawless driving—something to indicate not toleration but grave concern and determination to correct it.

To awaken the public: Double penalties on holidays!



The Expressway Impact on a Secondary Central Business District

MELVIN R. LEVIN AND DAVID A. GROSSMAN

Melvin R. Levin received the degree of Doctor of Philosophy in Planning from the University of Chicago in 1956. He has experience in the fields of city and regional planning, economic analysis and industrial development. His professional record includes the positions of Principal Planner for the Rhode Island Development Council, Project Leader of the Economic Studies Section, Midwest Research Institute and Area Development Director, Southern Illinois. Dr. Levin also was a partner in Blair Associates from 1957 to 1959, joining Advance Planning Associates in 1959.

David A. Grossman received from the Massachusetts Institute of Technology the degrees of Bachelor of Architecture in 1951 and Master of City Planning in 1953. His experience includes work as Chief Planner for the Urban Redevelopment Division of the Boston Housing Authority, Senior Planner for the Rhode Island Development Council and Director of the Eastern Kentucky Regional Planning Commission. In 1957, he became a partner in the firm of Blair Associates, planning consultants of Providence, Rhode Island. In 1959 he founded Advance Planning Associates in partnership with Dr. Levin.

OVER the past decade, the per-mile cost of intra-city portions of the interstate highway system has ranged from ten to one hundred times higher than inter-city parts. Enormous expenses are involved in land-takings, construction of complex interchanges, and generally in integrating expressways with other urban elements. An interesting facet of urban freeways is their potential contribution to solving of urban social and economic problems. Attempts have been made to use freeways as important factors in slum clearance and redevelopment activities, as supplements to inadequate local street systems, and as contributing elements in revitalizing problem-ridden downtown areas.

This article concerns one mile of Rhode Island's forty-seven miles of interstate highway. Specifically, the article analyzes economic impact on the downtown area of Pawtucket, of the new

Pawtucket River Bridge and its approaches. These comprise slightly more than a mile of Interstate Route 95.[1]

We have explored two fields that have received relatively little attention. The first is the *secondary* central business district, an area virtually ignored in comparison with the time, effort, and funds lavished on primary downtown areas. Secondly, we have related a functional analysis of the downtown area to the area's transportation system.

The article examines principal trends in Pawtucket's manufacturing, retailing and four other major downtown functions and indicates the probable impact of Interstate Route 95 and other transportation elements on these trends.

Pawtucket, a city of about 80,000 persons, directly adjoins Providence (population 225,000). In terms of retail sales and employment patterns, Pawtucket's downtown business district plays a distinctly secondary role to the Providence CBD with roughly one-third as much retail sales and total employment as its larger neighbor. Downtown Pawtucket is the economic focal point of the city, containing only six percent of Pawtucket's land area but seventeen percent of total assessed valuation. Most of the city's cultural, civic, office and financial functions, half its total retail jobs and over a third of its total employment is crowded into this 329 acre area.

THE ECONOMIC STRUCTURE OF DOWNTOWN PAWTUCKET

Unlike the situation in most central business areas in the nation where retail trade and office functions are the dominant influences, the employment pattern of downtown Pawtucket is dominated by

1. This article is based on the authors' work on Part II of a study of the effects of the North-South Freeway (part of Interstate Route 95) on economic activity, land use and traffic patterns in the downtown business area of the City of Pawtucket, Rhode Island. The study was sponsored by the Rhode Island Department of Public Works and the United States Bureau of Public Roads.

The entire study was divided into four major parts: I. Physical Inventory; II. Economic Framework; III. Traffic and Parking Survey, and IV. Future Development Plans.

Part II, as indicated in the original prospectus, was "devoted to a broad investigation of economic, market and population trends and their relation to emerging highway patterns as well as an analysis of the changing role of the (Pawtucket) central business district in terms of its business, civic, transportation and other vital functions."

Parts I and IV of the study were conducted by Blair Associates, Providence, Rhode Island, and Part III, by Wilbur Smith and Associates of New Haven, Connecticut.

manufacturing. In 1958, more than a third of all downtown jobs were provided by manufacturing firms. Retailing was second in importance, providing twenty-one percent of the total employment.

Categories in which the study area contains disproportionately large percentages of jobs as compared to the city as a whole include retail trade, transportation, communications and utilities, and finance, insurance and real estate. Manufacturing, extremely important as a component in the downtown area job pattern, represents less than a fifth of the city's total. Similarly, the wholesale trade, personal services, business services and construction categories are not significantly concentrated in downtown Pawtucket.

As compared with the Providence CBD, categories in which a proportionately larger share of downtown Pawtucket's jobs are concentrated include manufacturing, wholesale trade and transportation, communications and utilities. Downtown Pawtucket's job distribution pattern is approximately proportionate to its overall size in the categories of retail trade and government, while it has a disproportionately small share of its employment in three key downtown categories: personal services, business services and finance, insurance and real estate.

This is due to the fact that the Providence CBD performs a central role for the entire metropolitan area, including downtown Pawtucket, in certain fields, of which office-type functions are most prominent.

RECENT EMPLOYMENT TRENDS

The construction of the Pawtucket River Bridge section of Route 95 occurred from December, 1956, to November, 1958. During construction, unavoidable obstructions to traffic movement to and through the downtown study area were created. This disruption did not include the loss or dislocation of any significant amount of commercial or industrial property, although many potential customers for downtown stores were dislocated by the demolition or relocation of more than 300 residential structures. Dislocation in the commercial center was minor because the expressway ran along its eastern edge, rather than directly through the central district.

Total covered employment in downtown Pawtucket increased by ten percent during a period closely corresponding to the period

of expressway construction and during a business recession. Increases occurred in both the manufacturing and non-manufacturing sectors, although the rise in the former was far larger. When 1954 data are considered, however, the apparent gains in the 1956–1958 period appear less significant; manufacturing employment, for which the 1954 and 1958 coverage is comparable, shows stability rather than a significant gain.

Because of employment security coverage changes, 1954 non-manufacturing data for Rhode Island are not wholly comparable to 1958 data; if coverage changes are taken into account, it appears

TABLE I—COVERED EMPLOYMENT TRENDS IN DOWNTOWN PAWTUCKET STUDY AREA, 1954–1958*

Category	*1954*†	*1956*	*1958*
MANUFACTURING			
Textiles	1,062†	747	1,114
Non-textiles	2,032	1,895	2,077
Sub-total, Manufacturing	3,094	2,642	3,191
NON-MANUFACTURING			
Retail Trade	1,625	1,647	1,531
Wholesale Trade	135	144	332
Personal Services	69	88	99
Business and other services	165	266	329
Construction	173	173	120
Transportation, etc.	787	778	775
Finance, etc.	233	311	299
Sub-total, non-manufacturing	3,187	3,407	3,485
TOTAL	6,281	6,049	6,676

* Employment covered by the employment security program for September, a month which closely resembles the annual average. Excludes such categories as government, the self-employed and firms with addresses outside the city.

† Data for 1954 are not strictly comparable to 1956 and 1958 data, due to the fact that prior to January 1, 1956, coverage included only firms with four or more employees while after that date all firms with one or more employees were covered. This change had virtually no effect on manufacturing employment, but added about ten percent to the number of covered non-manufacturing employees on a state-wide basis. If this change had the same effect in Downtown Pawtucket as in the state as a whole, it would indicate that total covered non-manufacturing employment remained at about the same level (3,500 jobs) in the 1954-1956-1958 period.

that non-manufacturing employment as a whole also remained stable in the 1954–1958 period. Important changes, however, occurred within the non-manufacturing categories, including a decline in retail employment between 1954 and 1958 and substantial gains in wholesaling in this period.

THE RHODE ISLAND EXPRESSWAY SYSTEM

By 1960, after a decade of intensive road building, much of Southern New England had already been tied into the expressway grid developing in the northeastern part of the nation. In Connecticut, modern roads have assisted the expansion of industry and population radiating out of New York City. With the help of its Turnpike, Connecticut is attempting to overspill some of this expansion into the depressed textile towns in its eastern counties.

The Massachusetts Turnpike, extending westward from Boston along the state's main east-west axis of industrial development and population growth, provides a linkage to the industrial Connecticut River Valley, as well as to New York State and the Midwest via connections with the New York Thruway.

As in the case of its larger neighbors, Rhode Island has been engaged in the construction of a system of modern expressways designed to link its urban centers with other parts of New England and the nation. This system (of which the Pawtucket River Bridge is an important component) will make possible high speed travel both within the Providence metropolitan area and between this area and other urban centers. The map accompanying this article shows the existing and planned Rhode Island expressway system. (Figure 1)

When completed, the Rhode Island expressway network will consist of the following major connections from Providence and Pawtucket:

1. Connections to Boston and the Massachusetts Turnpike via Interstate Route 95.

2. Connections to southern Rhode Island and Connecticut via the southern part of Interstate Route 95.

3. Connections to Fall River, New Bedford and Cape Cod via Interstate Route 195.

4. A circumferential route around the built-up parts of the Providence area, Interstate Route 295.

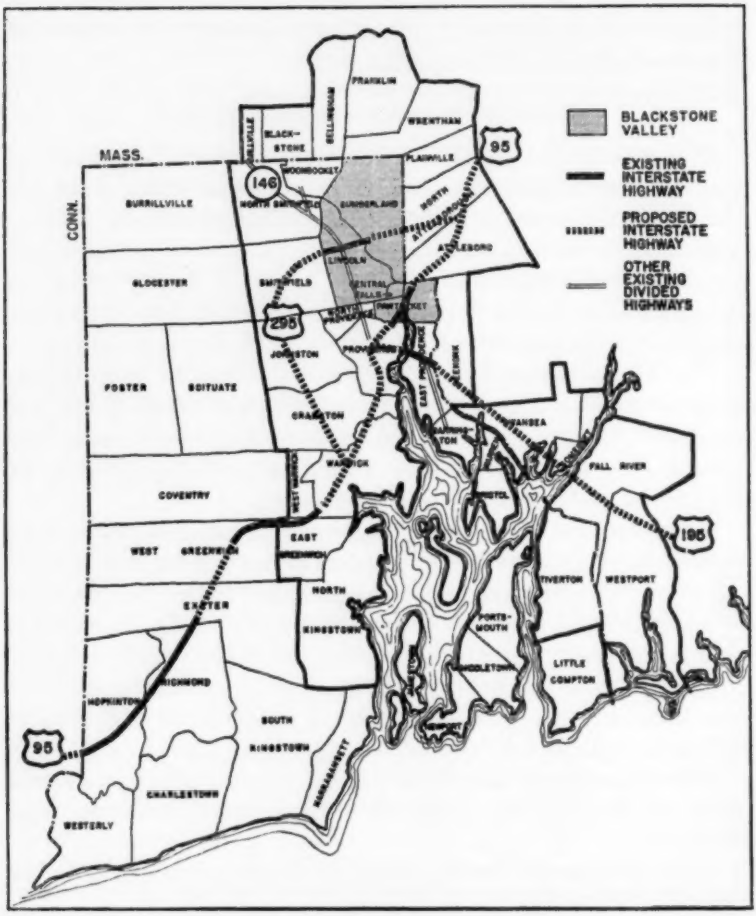


Figure 1. Downtown Pawtucket and the Freeway.

Other important highway connections include the Louisquisset Pike (Route 146) from Providence to Woonsocket (which will eventually be extended to Worcester, Massachusetts) and U. S. Route 6 west from Providence to the end of the Connecticut Turnpike at the town of Foster, Rhode Island.

As of 1960, the only completed road built to near-expressway standards in northern Rhode Island is the Louisquisset Pike. While this road bypasses Pawtucket it does pass through the adjacent town of Lincoln and its construction has been accompanied by considerable amounts of suburban expansion in that community.

Interstate Route 95 (of which the Pawtucket River Bridge was the first major element to be completed north of Providence) passes through the City of Pawtucket, but not through any of the communities of the Blackstone Valley which comprises the bulk of downtown Pawtucket's market area. When completed, Route 95 will greatly improve access from Pawtucket to Providence and the rapidly-growing southern portions of the Providence metropolitan area, as well as to Attleboro and other parts of Massachusetts to the north of Pawtucket.

Eventually, it will connect directly with the Boston metropolitan area. However, with the sole exception of the southern part of the city of Attleboro, Massachusetts, this highway will not connect downtown Pawtucket with any of the communities which have traditionally been a part of its primary market area.

The projected circumferential highway around the Providence area (Interstate Route 295) appears certain to have an important effect on the economy of downtown Pawtucket. While detailed consideration of the potential impact of this highway was beyond the scope of the study, it appears pertinent to note the following facts:

1. This road will parallel in many ways the pattern of the circumferential highway of the Boston metropolitan area, Route 128. The construction of Route 128 has stimulated considerable amounts of industrial, commercial and residential development in the communities through which it passes.

2. Virtually all of the industrial and commercial development along Route 128 (ninety-six percent of all firms) consisted of expansion or relocation of existing Boston area firms, most of them

from within four and one-half miles of the central city itself.[2]

3. The expansion along Route 128 coincided with overall economic growth in the Boston metropolitan area and especially the expansion of research-oriented electronic industries. In contrast to the Providence metropolitan area, the diversified economy of the Boston area has not been seriously affected by decline in the textile industry.

It appears certain that the Providence area's circumferential route will attract industrial and commercial enterprises. To some extent these plants will consist of firms wholly new to Rhode Island; based on Boston experience, however, most of the firms locating along the route are likely to be relocations from the central cities such as Providence and Pawtucket. While the state as a whole may benefit through industrial expansion in connection with the circumferential highway, benefits to the state and to suburban communities must be balanced against potential losses in employment, taxable values and sales potential in the central cities of the area.

TRANSPORTATION FACTORS AND THE CBD

Efficient transportation systems are a pre-condition for the development of central business districts which, of necessity, are situated some distance away from the labor force they employ and the population they serve. However, an identification of the precise effect of transportation factors on the changing functions of central business districts is a far from simple task. One problem arises out of the complex inter-relationships between the economic functions themselves.

For example, declines in the sales volume of convenience shopping establishments may be related to a decline in downtown manufacturing employment rather than being directly related to reductions in mass transit or other transportation factors. Similarly, an increase in new office space may involve a transfer of office activity from manufacturing production buildings to separate quarters, a regrouping of scattered offices or fission of large office establishments. Transportation may or may not be a significant factor in each of these developments.

2. *Economic Impact Study of Massachusetts Route 128.* Prepared for the Massachusetts Department of Public Works and the U. S. Bureau of Public Roads by the Transportation Engineering Division, Massachusetts Institute of Technology, December, 1958.

Another problem arises in assessing the importance of transportation as compared to other items. This is especially the case in downtown Pawtucket's retailing operations. Completion of Route 95 and other developments may increasingly permit the downtown area to compete with rival centers on more equal terms by reducing the serious transportation problems which formerly handicapped it; however, the promotion and pricing policies adopted by downtown merchants may in some cases be as important in determining the distribution of retail sales as relative transportation advantages.

Perhaps the most difficult problem of all is attempting to isolate the effect of transportation factors within the broad complex of technological changes, the profound alterations in social attitudes and the shifts in consumer income and expenditure patterns which have been taking place in recent years.

EFFECT OF TRANSPORTATION SYSTEMS

In particular, one major change affecting the economy of Rhode Island and the Blackstone Valley, the decline of the textile industry, appears to have had, at most, only an indirect relationship to transportation. Transportation undoubtedly has played a role in many important trends, including suburbanization, but its precise importance must necessarily be a matter involving a certain amount of conjecture.

The difficulties of relating transportation factors to changes in urban activities have been well stated by Horwood and Boyce in their recent book:

> There are a number of variables, conditioned by the freeway network itself and imposed by other activities, which preclude the segregation of highway impact from other factors that also exert considerable effect on the CBD. These include extent of the freeway network and its degree of completion, the characteristics of the inner-distributor loop, the amount of space utilized for freeways, the degree of linkage interference by freeway splitting of land functions, the degree of centralization or decentralization of activities, the extent of planning and urban redevelopment, the development of mass transit, the provision for off-street parking, and changes in the CBD itself which are occurring independent of highways.[3]

The following discussion is concerned with each of six primary

3. Horwood, Edgar M., and Boyce, Ronald R., *Studies of the Central Business District and Urban Freeway Development*, University of Washington Press, Seattle, 1959. p. 125.

downtown functions as their growth or decline is related to transportation factors.[4] Each of the functions is analyzed in terms of trends in the national urban economy and the analysis is then related to the specific conditions obtaining in downtown Pawtucket. Insofar as possible, the influence of transportation on each of these economic functions has been isolated.

1. *Manufacturing activities* were at one time the dominant element in many downtown areas; however, recent changes in production and transportation techniques tending toward a combination of one-story structures on large sites and easy highway access have led to a shift of manufacturing industry away from the obsolescent multi-story structures and the environmental problems of downtown areas.

Contrary to the overall trend, certain specialized manufacturing operations linked to office and communications functions have tended to remain in certain areas. This has also been true of some loft-type operations which require low-cost factory space. In terms of numbers of employees, however, the trend is clearly downward in most central urban areas.

Downtown Pawtucket appears to have shared in the nationwide trend toward a decline in downtown manufacturing, although it is not possible to determine the extent to which its decline has been the result of locally depressed industrial conditions and how much it is a part of a nationwide tendency. In recent years manufacturing job losses in Pawtucket's central area have been relatively minor. Downtown Pawtucket has been fortunate in that its industrial structure, while dominated by textile production, has proved more resistant to downturns in employment than is generally the case in the state and metropolitan areas.

This relatively favorable downtown manufacturing pattern is closely associated with the work of Pawtucket industrial development and civic groups which have succeeded in filling most of the downtown area's vacant textile mills with new types of economic activity. Partly through their efforts, the six to seven million square feet of vacant mill space available in the entire city in the 1930's had dwindled to 630,000 in 1959.

4. The functional analysis used in this article owes much to the pioneering work of Raymond Vernon in his publication *The Changing Economic Function of the Central City*, (Committee for Economic Development, New York, 1959) and in the New York Metropolitan Region Study of which he was Director.

Less than 50,000 square feet of manufacturing space, only half of it readily usable, was available in the downtown study area in 1959. However, not all of the progress in filling vacant space has been due to finding new industrial occupants. Some large Pawtucket mills have been converted into mill outlets, a process that has converted structures which once generated consumer sales into establishments competing with downtown stores. Other mill buildings now house supermarkets, automobile showrooms or other types of non-manufacturing activities.

The manufacturing activities of downtown Pawtucket have historically relied on two main types of transportation: rail service for goods receipt and shipment and public transit (trolleys and later buses) to bring workers to the plant. The road pattern of the central city, at least prior to the construction of the Pawtucket River Bridge, had relatively less to offer to manufacturers, especially since widespread use of the motor vehicle resulted in congestion of the area's narrow, winding streets.

With the shift of many workers from a reliance on public transportation to use of their own automobiles, downtown Pawtucket locations have lost one of the unique advantages they once possessed: ready access to a large labor force is no longer a downtown monopoly. Similarly, the shift from rail to truck use for goods shipment has lessened another advantage formerly reserved for downtown manufacturers. Despite these changes, downtown Pawtucket has maintained stability in its manufacturing employment level in recent years. This fact represents a considerable achievement. This level may not be maintained in the future unless at least some of the major non-transportation handicaps of the downtown area can be overcome. That was indicated from a survey of study area manufacturers.[5]

Interviews and questionnaires revealed that site and building problems and other environmental factors are now paramount considerations for manufacturers. In the future, major consideration must be given to overcome the problems presented by obsolete buildings, lack of land for expansion and other non-transportation factors. A promising step in this direction could be taken if, through

5. This survey, other results of which will be cited in following portions of the article, consisted of personal and telephone interviews with 65 percent of all business firms in Downtown Pawtucket in September, 1958.

the use of urban renewal techniques, land could be made available for construction of modern manufacturing plants in or near the downtown area. It must be recognized, however, that even with a major effort it will not be possible to provide sites attractive to all types of industry. The general trend in central areas throughout the nation indicates a continuing decline in their importance as manufacturing centers compared to suburban locations; this trend can be slowed by appropriate action, but it would appear unrealistic to expect that it can be reversed, despite improvements in transportation.

2. *Retail Trade:* Usually the single most important downtown function from an economic standpoint, retail trade sales volume and employment, has been declining in most of the nation's central business districts. The forty-eight largest central business districts in the nation averaged only a 1.6 percent retail sales volume increase from 1948 to 1954, a figure that falls far below the twelve percent increase that would have been necessary to keep pace with inflation. None of these CBD's improved its position vis-a-vis its metropolitan area as a whole.

Similar figures are not available for secondary business centers such as Pawtucket, but it seems probable that in most instances, sales have been falling off in recent years at least as rapidly in secondary areas as in primary business districts. Although no sales volume figures are available upon which to base a sales trend, the decline in downtown retail employment which occurred in the study area between 1954 and 1958 is probably indicative of a similar decline in downtown retail sales.

Support to this hypothesis is lent by survey returns which revealed that only about one quarter of all retail stores in downtown Pawtucket responding to the survey reported increased sales volume between 1957 and 1958. Further indications of Pawtucket's downtown retail trends are revealed by an occupancy survey which indicated that in 1959 almost a fifth of ground floor retail space in the heart of the study area was vacant.

One of the most serious problems confronting downtown retailers in parts of New England is competition from mill outlets that have made serious inroads on the downtown market. A reason for the relatively greater strength of mill outlet operations as com-

pared to downtown stores can be found in the overall trend toward suburbanization of population and retail trade. (However, as two mill outlet-type operations in Pawtucket but outside the downtown area indicate, competition with the CBD need not be confined to the suburbs.)

MILL OUTLET COMPETITION

Furthermore, Pawtucket's downtown merchants have not countered the competition effectively; their efforts to stem the inroads made by the mill outlets have been tardy and minimal. To cite a striking example, no serious attempt to match mill outlets' late hour openings was made until 1959, approximately five years after the threat from this source became apparent.

To return to the national picture, a renewal of recent downward trends in CBD retail sales has been the avowed objective of many recent downtown development studies. On the basis of long term trends toward suburban diffusion of population and work places and the parallel decline in important CBD functions, however, it is difficult to see how central business districts can maintain even their 1960 standing relative to their metropolitan areas. Much of their present efforts seem to be in the nature of holding operations, aimed at limiting potential future losses.

In general the principal approaches toward a regeneration of downtown retailing can be summarized as follows:

1. Increased promotional efforts
2. Improvement of highway access
3. Construction of additional parking facilities
4. Urban renewal aimed at introducing new industrial, office and residential development
5. Esthetic improvement of downtown areas combined with easing of pedestrian movement through such developments as malls
6. Subsidization of mass transit

Unfortunately, co-ordinated efforts embodying all or most of these points are rare and therefore their net effect on downtown retailing must be more a matter of faith than of measurable progress. It does appear that they may provide some of the pre-conditions hitherto lacking for more effective competition on the part of downtown stores. In Pawtucket, for example, recent progress in

improving vehicular access and parking facilities has removed some of the disadvantages which formerly prevented the downtown area from meeting competitors in outlying areas on equal terms.

Nevertheless, Pawtucket retailers will continue to labor under certain disadvantages. These include (1) high downtown taxes and rentals, (2) a pattern of absentee ownership and neglect of some downtown properties, (3) the probable loss of a portion of the captive manufacturing market and (4) further reductions in the mass transit service which transports thirty-eight percent of the shoppers to the downtown area.[6]

Retailing activities are directly and vitally affected by transportation developments. That this is fully realized by downtown Pawtucket merchants is indicated by returns from the questionnaire survey. Fully two-thirds of the suggestions volunteered by retail respondents for the improvement of downtown Pawtucket involved complaints, suggestions or other remarks involving the local transportation system.

It is important that the view of local retail merchants is firmly centered on their immediate surroundings: comments on the parking situation led by a wide margin, followed by suggestions on streets, mass transit and other local traffic conditions, while less than five percent of the total comments related directly to the new expressway. In understanding this reaction it is useful to consider retail operations in downtown Pawtucket in relation to each of the major transportation components:

a. *Street Circulation:* The topographic setting, physical layout and distribution of business enterprises of downtown Pawtucket present a number of difficult problems in evolving an efficient street circulation pattern satisfactory to all of the firms and individuals concerned. A combination of steep grades, narrow, winding streets and scatteration of firms militates against any solution which will be wholly agreeable to all downtown businessmen.

Questionnaires and interviews revealed a substantial number of suggestions on the existing street pattern in regard to traffic regulation and enforcement which, if accepted as a basis for action, might result in an equal number of complaints by persons who

6. Wilbur Smith and Associates, *Trade, Transit and Traffic*, Providence, Rhode Island, May, 1958. pp. 34.

believed themselves unfavorably affected by the changes. There also seemed to be instances in which local traffic conditions received a disproportionate share of the blame for economic losses created by broad economic trends (e.g. unemployment resulting from the downturn in the textile industry). It is also apparent that despite much evidence to the contrary, many retail merchants strongly believe that there is a positive correlation between traffic congestion and high sales volume.

b. *Parking:* A good deal of progress has been made in creating new off-street parking lots in the study area. Some respondents felt that these efforts had assisted retailing in the area to decelerate the loss of sales to the suburbs. In fact, a few stated a belief that the downtown area is over-parked. However, fully a quarter of the comments in the questionnaires expressed sentiments in favor of additional downtown parking space.

On the whole, analysis seems to bear out the comments of those retailers who stressed the beneficial effects on retail sales of recent progress in expanding the number of parking spaces in the downtown area. It also seems apparent that the problem of improving access from parking areas to stores has not yet been resolved.

c. *Mass Transit:* The deterioration of bus service (the only available form of mass transit) occasioned numerous complaints and suggestions by downtown merchants. Although mass transit does not carry as large a proportion of Pawtucket's downtown shoppers and employees as is the case in Providence, declines in service and rises in fares have caused great concern among Pawtucket retailers.

They peer gloomily into a future in which bus service is reduced to a bare minimum, cutting them off from their labor market and from many shoppers. They feel that since mass transit is an extremely important consideration in one-car (or no-car) families and among non-drivers, continued falling off in bus service coupled with high fares can only further weaken downtown Pawtucket's position.[7]

d. *Interstate Route 95:* The new expressway did not appear to be a matter of great concern to downtown merchants, based on their responses to the survey questionnaire, perhaps partly because it

7. Bus service to Downtown Pawtucket has declined sharply in passengers carried in recent years. The number of passengers carried by buses fell by 40 percent from October 1954 to October 1958.

does not directly link downtown Pawtucket with the bulk of its primary suburban market area and partly because only a small portion of the expressway had been completed at the time of the survey. Comments manifested two contrasting attitudes, the first being a tendency to assign the expressway some of the blame for recent downturns in sales volume, and the second to express pleasure in the way it had reduced executive commuting time and relieved downtown congestion. Not far beneath the surface, however, lies a feeling of apprehension regarding the effects of the completed expressway and other highways on future downtown sales volume.

Some merchants seem to believe that, when completed, the expressway will work to the disadvantage of downtown Pawtucket by making it easier for a portion of the area's present market to shift its shopping allegiance to the larger Providence central business district, while another portion of the market turns to shopping in outlying suburban stores.

Other retailers, particularly proprietors of restaurants, drugstores and other convenience shopping enterprises, blame the expressway for destroying part of their market by demolishing housing units and cutting off easy access from nearby residential areas.

To a degree, the merchants who await the completion of the expressway (along with other major highway improvements) with trepidation rather than confident anticipation reveal a tendency to doubt their ability or the effectiveness of the downtown area as a whole to compete effectively when highway advantages within the metropolitan area are equalized. Analysis does not indicate that future economic levels are predetermined in favor of any one area and a number of downtown Pawtucket stores which have already shown up well against stiff competition and in the face of local economic decline can be expected to perform well in the future. It does seem clear, however, that a broadening of competitive horizons on the part of downtown merchants will increasingly become necessary as the highway program levels off transportation advantages between competing areas. Action to adjust promotional policies, downtown parking and store hours to changing conditions will be essential if the area's merchants are to take full advantage of the expressway's potential.

3. *Wholesale Trade* activity generally has tended to shift away

from downtown centers. An important distinction exists, however, between wholesaling without stock which is primarily an office function, and wholesaling with stock which often requires substantial amounts of warehouse space.

Change-over from rail to truck transportation, the growth of suburban markets and technological changes in goods handling have created a demand for the same type of one-story buildings for wholesalers with stock that is characteristic of many modern manufacturing operations. It is noteworthy that a good deal of space in suburban industrial parks in Rhode Island and elsewhere is occupied by wholesalers.

Wholesaling activities differ in response to transportation factors. Wholesalers with stock (essentially warehouse operations) resemble manufacturers in their reliance on trucking and in their need for good regional and local access to receive and ship goods. Transportation improvements which assist manufacturing operations should be of direct benefit to wholesalers of this type.

To the extent that wholesalers also engage in retail activities, the comments above on retail needs in transportation would apply. Wholesalers without stock are primarily office operations conducting much of their business over the phone or by mail with a limited number of salesmen and customer visitors. Transportation factors important to such firms are those which apply to office operations.

4. *Office* activities are one of the fastest growing functions in a number of the nation's larger cities. In considering this function, it is necessary to distinguish between the various categories which use downtown office space.

The fact that downtown office space is comparatively expensive is frequently a minor consideration to firms seeking downtown headquarter sites; they can well afford the utility and prestige of a central location. However, there seems to be a definite tendency toward wide differentials to develop in rates of office expansion between the nation's cities.

New York City, for example, is increasingly becoming the central corporate and financial headquarters for the entire nation, although other regional centers such as Boston have also benefited from this type of expansion. Outside of major cities, office expansion has been limited. Thus far, downtown Providence has been

the site of only one major new office building in the post-war period while in the Pawtucket CBD only one small office structure, an insurance office, has been constructed in recent years.

As compared to the Providence CBD, Downtown Pawtucket has developed only a limited office function. Most of its financial institutions and many of its business offices are relatively small branch operations of Providence firms. The city's CBD has few ancillary office activities such as advertising and employment agencies, nor is it the site of numerous large corporate headquarters buildings. Further, the manufacturing firms located in the downtown area have retained their office functions on an integrated basis with their production operations.

In view of the predilection of corporate and financial office functions for large cities and the limited growth expected by office operations now located in Downtown Pawtucket, it would not appear that much expansion can be anticipated from this source. More than twenty percent of downtown office space is now vacant and it is noteworthy that only ten percent of all downtown office occupants indicated a need for greater space requirements in the next five years.

The primary transportation requirement for offices is good access and parking for employees and executives, although some office operations, such as banks, have a large customer inflow. To a great extent, therefore, offices have transportation problems similar to those of the retail stores discussed above, except that some office operations have no substantial customer traffic.

Office operations in downtown Pawtucket which depend on customer contact or which require substantial numbers of transit-borne employees have been adversely affected by the decline in mass transit, while executives and other employees of downtown offices have benefited from improvements in the local street system, expanded parking facilities and construction of the new expressway.

Completion of the expressway will directly benefit offices which are not in a competitive relationship with other locations. It may, however, intensify locational competition for some office operations now located in the study area, especially professional service activities.

5. *Government* activities differ markedly from the functions discussed above not only in their non-commercial nature, but also in

the fact that they are relatively immobile and have been tending to expand in small as well as large urban centers. Central business districts normally contain the city hall and varying amounts of state and federal offices.

In downtown Pawtucket, government provides a thousand jobs, about a tenth of the captive market employment vital to convenience shopping establishments and other retail enterprises. By their very nature, government headquarters functions must remain downtown. City Hall, to cite the most important source of Pawtucket government employment, is certain to remain on its present site.

Government operations in downtown Pawtucket are primarily of an office nature, but they have certain additional characteristics which create transportation needs over and above good mass transit and highway access. A number of government operations require a large amount of public contact, including licensing, tax, postal, security and welfare functions. In addition, there is a special problem in that the city's main police and fire stations are in City Hall, located within the Study Area. Government operations in Downtown Pawtucket therefore combine the transportation requirements of office and retail functions, plus a special need for 24-hour city-wide access for police and fire equipment.

6. *Residential functions*, once significant in central business districts, have shrunk in many downtown areas to the point where rooming houses and substandard housing comprise the bulk of remaining dwelling units. On the whole, housing in Downtown Pawtucket is not of the generally low quality found in many other central business districts, but housing conditions are unsatisfactory in certain parts of the area.

The comparatively small amount of housing downtown makes the changes wrought by the expressway highly significant. This is particularly the case because of the importance of nearby residents to Pawtucket downtown shipping. In 1959, sixteen percent of the retail shoppers in Downtown Pawtucket arrived in the CBD on foot. It is important therefore that expressway construction has already demolished 350 residential structures while approximately fifty more will be destroyed when the highway is extended.

A limited counter trend toward construction of high rise, high rent apartments in and near downtown areas is in evidence in some parts of the nation. Thus far no such tendency has been apparent

in the Providence metropolitan area. Clearly, the market in Pawtucket for such housing is likely to be limited.

Residential activities originally developed in and near downtown areas because of the proximity to workplaces, shopping and trade facilities. With the growth of mass transit systems, population began to move outward. As housing in downtown areas fell into decay, and as the use of motor vehicles became more widespread, proximity to downtown became less important than the amenities provided by outlying areas.

Suburban expansion on sites far removed from the central city has required lengthy commuting trips. Expressways and other transportation developments have alleviated but have not solved the journey-to-work problem of the suburban resident. In regard to shortening the journey-to-shop many residents of suburban areas find a simple solution by patronizing outlying retail centers and service establishments.

In conjunction with urban renewal programs attempts have been made to provide housing near downtown areas for persons and family units preferring this type of location. However, high land and construction costs generally limit the choice in such housing to multi-family dwellings at substantial rents. These factors, added to a continuing nationwide preference for single family detached housing and suburban amenities have severely limited the amount of new downtown housing despite its transportation advantage. Unless consumer housing desires change or unless some means is found of drastically lowering rents, it does not appear that this situation will be reversed. Clearly, the case of downtown housing appears to be an instance in which demonstrable advantages in transportation time and expense are outweighed by other factors.

CONCLUSIONS

The various functions of the Pawtucket central business district require an adequate transportation system as a basic prerequisite for their continued viability. The serious problem raised by the deterioration of mass transit service to downtown Pawtucket has had adverse effects on downtown retailing operations and other functions such as office activities which employs large numbers of person who depend on bus service.

The decline in mass transit has been accompanied by improvement in motor vehicle routes and parking facilities. Further progress in expanding the number of accessible downtown parking spaces and in reworking internal street circulation will be of benefit to virtually all of the major CBD functions. However, because of the physical inefficiency of the private motor vehicle in relation to the limited amount of space in downtown areas, it does not appear that any feasible solution to the economic problems of these areas can be achieved in the absence of mass transit. Based on the preceding analysis, the following statements appear valid:

1. The decline in mass transit which is symptomatic of suburban trends and which is nationwide in scope has adversely affected Downtown Pawtucket's retail and other functions which depend on a non-driving or non-car-owning population.

2. Recent improvements aiding motor vehicle users (including the completed portion of the expressway) have assisted most elements in the downtown economy and have partially compensated for the decline in mass transit.

3. To date, the expressway appears to have had limited effects on the economy of the downtown area. It has had a direct impact on the area's residential function in removing over 300 downtown residences, but because its passage was through a residential district, somewhat removed from the central core of the downtown area, its *immediate* impact on commercial and industrial business volume, operations and physical distribution was reduced to minor proportions.

Up to the present, the expressway's economic effects on the downtown area do not appear to be highly significant; most of the basic economic trends affecting downtown, particularly the decline in retail sales volume and employment and changes in other CBD functions seem to have begun before Interstate 95 was conceived.

4. The expressway's *long range* impact on most downtown operations will be substantial, especially as connecting links to Providence and Boston are completed. The final results of the creation of easy vehicular access to Downtown Pawtucket are not wholly foreseeable at this time.

It appears certain, however, that new expressway construction,

coupled with related transportation improvements, will tend to reduce the area's past transportation handicaps. While the state and the Blackstone Valley as a whole are likely to reap substantial benefits from the completed expressway systems, no simple pattern of economic benefits can be anticipated in downtown Pawtucket.

Most manufacturing and wholesaling activities located in the downtown area are likely to receive important benefits through improvements in employee access and reductions in the time and costs involved in transporting goods as a result of expressway construction.

Some benefits will accrue to downtown retailers through improved highway access. The fact, however, that retailers in the central business district are in competition with stores in outlying areas raises questions regarding the expressway's impact on downtown retail operations.

The expressway, along with other highway improvements, may equalize transportation advantages throughout much of the metropolitan area, bringing downtown stores into a more direct competitive relationship with stores in outlying locations and with the Providence central business distrcit. Only to the extent that downtown merchants can thrive in this environment of intensified competition will Pawtucket's downtown retail activities benefit.

5. The City of Pawtucket, which depends for much of its tax revenue on the downtown area, will reap benefits from the expressway if downtown (and other Pawtucket) business operations can compete successfully with business activities in other communities in the face of improved area-wide access.

6. The residential function of the downtown area has already been reduced and will be further curtailed by future expressway construction.

The construction of Interstate Route 95 and other improvements in highway and traffic facilities will result in clear benefits to most downtown functions, but will present Pawtucket's downtown merchants with a challenging situation, which, depending in part on their efforts, can be viewed as either a threat or an opportunity.

This analysis of downtown Pawtucket indicates a difficult future for the secondary business district. The secondary downtown area lacks important sources of growth and stability found in pri-

mary urban centers such as large private and government office buildings, downtown hotels, major department stores, a wide range of cultural activities and attractiveness for high-rise, high rent apartments.

These functions provide both the basis for past economic growth in major downtown areas and the justification for massive efforts aimed at their continued viability. The secondary business center, on the other hand, often specializes in functions which possess less internal vitality than those which dominate primary centers. In Pawtucket, for example, downtown retailing activities have proven extremely vulnerable to outside competition and it appears likely that major manufacturing operations will shift to suburban locations in coming years.

The great improvement in vehicular access which will result from the completion of the interstate highway system and other road construction would not seem to alter significantly the bleak prospect for the secondary business district.

Assuming that related problems of mass transit and parking can be successfully resolved, it is conceivable that new expressways may help to halt the decline in certain economic functions of primary metropolitan business centers.

Realistically, however, no such statement can be made about the secondary business center, even if its transportation problems can be brought under control, because the potential for further declines in vital economic functions far overshadows their growth potential.

Benefit-Cost Methods for Evaluating Expressway Construction

IRVING HOCH

Professor Hoch is a member of the faculty of the Department of Agricultural Economics, The University of California (Berkeley). From 1956 to 1959 he was on the staff of the Chicago Area Transportation Study, and was chief of the Economic Analysis Section when this accident study was made. He holds a Ph.D. degree in Economics, and is a member of the American Economic Association, the Econometric Society, the American Statistical Association, and the Regional Science Association.

IN evaluating benefits and costs of expressway construction, the following outline is an initial statement of proposed methods:

1. Specify a before and after situation. The before-situation may consist of the present street system, or it may consist of the present system plus definitely committed expressways. It may be the present system at the present time, or it may be the present system carried forward in time. Projected traffic volumes would move through the present street network with no additions to the network.

AUTHOR'S NOTE: This article outlines some general procedures for calculating benefits and costs of expressway construction. It is based on research performed at the Chicago Area Transportation Study (CATS). Results have been incorporated in the Chicago study's evaluation of plans for the Chicago area. The procedures discussed here, however, abstract (or can be generalized) from the particulars of the Chicago area, and should have general applicability to problems of metropolitan area expressway construction.

AUTHOR'S ACKNOWLEDGMENTS: This study was a research project of the Chicago Area Transportation Study under the direction of J. Douglas Carroll, Jr., Study Director. It drew on earlier benefit-cost work performed at the Detroit Transportation Study by H. W. Bevis and E. W. Campbell. H. Joseph and M. Khan served as research assistants on the phase of the work reported here; this work was subsequently carried forward and incorporated into the Chicago Study's highway plan evaluation procedure by H. Joseph and G. Haikalis.

The after-situation can range from the present system plus one short section of new expressway to the present system augmented by a full network of proposed expressways.

2. For both situations, it is assumed the following data are given:

a. Traffic volumes for each link of the given system (where a link is a particular section of the system). In the Chicago study, these volumes were estimated by a traffic assignment procedure.[1]

b. Average twenty-four-hour speeds on each link. The average twenty-four-hour speeds can be obtained using estimated relationships between speed and volume. If link volume is given, then the average speed on that link can be estimated, using a general speed-volume relationship.[2] (A possible generalization would be the use of speed and volume distributions rather than averages. For the present, however, the use of twenty-four-hour averages seems a necessary simplification.)

3. For each situation, use the link volume and speed data to obtain the distribution of vehicle miles of travel by average speed. Thus, say there are sixty-five million vehicle miles in a 1980 before-situation (for example, the present street system plus a minimum expansion of the network), of which one million vehicle miles are at eight miles an hour, one million are at nine miles an hour, two million are at ten miles an hour, . . . , six million are at fifteen miles an hour, . . . , etc. The calculation of this distribution should be a fairly straightforward application of the data in step 2.

4. For each speed a corresponding cost to vehicle occupants can be specified. This cost includes time cost, operating cost, and accident cost. A table relating costs to speed has been derived and is summarized in Table I. A detailed discussion of the sources of the table entries appears in a later section of this paper. The table lists costs per mile in cents. (Parenthetically, it is of some interest that minimum cost occurs at fifty miles an hour.)

5. Given the distribution of vehicle miles by speed, a total cost figure can be derived for both situations by multiplication of total

1. Cf., M. Schneider, "Gravity Models and Trip Distribution Theory," *Regional Science Association, Papers and Proceedings*, 1959; and J. D. Carroll, Jr., "A Method of Traffic Assignment to a Network," *Trip Characteristics and Traffic Assignment*, Highway Research Board Bulletin 224, Washington, D. C., 1959.

2. General speed-volume relationships were developed at CATS by E. Wilson Campbell, L. Keefer, and R. Adams.

vehicle miles at each speed by the cost at that speed and then summing results for each speed to obtain a total cost. It may be noted that this procedure accounts for the "adverse travel cost" problem (where adverse travel is the extra travel occasioned by drivers going out of their way to use expressways). Adverse travel will be a component of the after distribution of vehicle miles by speed.

TABLE I—VEHICLE OCCUPANT COSTS RELATED TO SPEED

Average speed miles per hour	*Cost of vehicle occupants cents per mile*	*Average speed miles per hour*	*Cost of vehicle occupants cents per mile*
5	43.7	21	11.8
10	23.2	22	11.2
11	21.2	23	10.8
12	19.5	24	10.4
13	18.3	25	10.0
14	17.0	30	8.4
15	16.1	35	7.5
16	15.2	40	6.7
17	14.4	45	6.5
18	13.7	50	6.4
19	13.0	55	6.5
20	12.3	60	6.6

As a simple artificial example of this procedure, consider the before and after situation in Table II. (Magnitudes used in this example were made as realistic as possible on the basis of information available at the time of this work.) There are sixty-five million vehicle miles of travel in the before case, seventy million vehicle miles of travel in the after case.

TABLE II—A BEFORE AND AFTER SPEED-VOLUME AND COST EXAMPLE

	Volumes		
Speed miles per hour	*Before*	*After*	*Cost per vehicle mile cents per mile*
	millions of vehicle miles per day		
5	3	2	43.7
10	7	3	23.2
15	15	5	16.1
20	10	5	12.3
25	10	10	10.0
30	5	5	8.4
40	15	40	6.7
Total vehicle miles	65	70	

Cumulative multiplication of cost times vehicle miles yields a total vehicle occupant cost of $9 million a day in the before case; $7.1 million in the after case. This implies a daily benefit of $1.9 million (costs before minus costs after). There are 340 weekday equivalents in a year; hence, yearly benefits total $646 million. (This treats week-end days and holidays as equivalent to .7 of weekdays, on the basis of relative traffic volumes.)

6. Given the yearly benefits, obtain an estimate of costs and compute benefits minus costs. Time considerations and the market interest rate are factors here and will be considered in more detail in following sections. As an example of the kind of procedure involved, consider the following: Assume benefits are the $646 million a year of the preceding example. Define the life of the expressway and select an appropriate interest rate. Thus, expressway life is set at twenty-five years and the appropriate rate of interest is taken to be the market rate of interest and is set at five percent. Capitalized benefits can then be obtained by dividing yearly benefits by .071; the .071 figure includes an interest component of .05 and a depreciation component of .021 reflecting the assumed life of twenty-five years.

Thus, at equilibrium, for each dollar of capital value, returns per year consist of five cents in interest plus a depreciation component of 2.1 cents which will compound to the original dollar invested at the end of twenty-five years.[3] (This assumes the same amount is returned each year.) Capitalized benefits of $646 million a year then become $9.1 billion.

Costs can be obtained by summing right-of-way and construction costs and adding to this capitalized maintenance costs. Suppose the after-situation involves additional construction of 400 miles of expressway at $5 million a mile. Costs are $2 billion and benefits minus costs are equal to $7 billion of "social profit."

It is assumed in this argument that construction and right-of-

3. If expressway life is treated as infinite and the market interest rate is five percent, divide benefits by .05 to obtain capitalized value of benefits. If expressway life is treated as finite, divide by $.05 + r'$, where r' is a depreciated component given by this formula:

$$r' = \frac{r}{(1+r)^T - 1}$$

where T is expressway life; r is the interest rate. Thus, if $T = 25$ and $r = .05$, then $r' = .021$. The approximate divisor of benefits in capitalization is thus .071.

way costs can be estimated on the basis of past experience. (That estimation procedure is treated as a separate problem for the purposes of this paper.)

SOME AREAS OF APPLICATION

The before-after approach can be applied to a number of situations. The following may be noted:

1. Comparison of a present street network to a network containing a "full" system of expressways.

2. Comparison of a present street network to several alternative proposed networks and selecting the "best" network. Thus, say three plans (I, II, and III) are proposed, and "social profits" are as follows: Under I: $7 billion; Under II: $4 billion and Under III: $8 billion. This implies plan III is "best."

3. Profits for the marginal expressway can be determined. Thus, where there is some question as to whether a given expressway should be included in the final network, the after figure obtained for Table II included this marginal expressway. It could be omitted from the planned network and the effect on vehicle miles and costs could be examined. Table III continues the previous example by exhibiting the hypothetical effects of such an omission.

TABLE III—HYPOTHETICAL EFFECTS OF OMITTING AN EXPRESSWAY FROM THE PLANNED NETWORK

Average speed miles per hour	*Volumes (after exclusion of marginal expressway) millions of vehicle miles*	*Cost per vehicle mile cents per mile*
5	2	43.7
10	3	23.2
15	5	16.1
20	5	12.3
25	10	10.0
30	6	8.4
40	39	6.7
Total	70	

Total travel cost in the new after-situation (without the marginal expressway) is $7.107 million a day; in the old after-situation, it was $7.090 million a day. Savings with the marginal expressway in the network amount to $.017 million per day and $5.7 million

a year. Capitalized, this is about $80 million. Assume the marginal expressway is 10 miles long and costs $10 million a mile, so that its total cost is $100 million. Since costs here exceed benefits, it can be concluded that the marginal expressway should not be constructed.

4. Net social benefits for parts of the system can be estimated. Thus, there may be some question as to how far the expressway system should extend from the metropolitan area center. The proposed network can be divided into an inner and an outer zone, and the network in the outer zone can be treated as a marginal part of the system. It can then be evaluated in the same way the marginal expressway was evaluated.

5. This same procedure could be applied to a particular section of a particular expressway. The smaller the unit, the closer the situation approaches the ideal for analysis. Logically, one should continue to add small increments of expressway until the increment to benefits from an additional section just equals the increment to costs of that section. Budget limitations, however, may preclude analysis of even large sections of expressway treated as marginal.

Within the budgetary restrictions, there may be a desire for information on a return to a particular area, giving some insight into returns to a particular expressway or section of an expressway. Thus, instead of obtaining a traffic assignment with the section included in the network and an additional assignment with the section excluded, budget restrictions might limit the analysis to results obtained from one over-all assignment.

In this case, some useful results may be obtained by defining an area of influence of a given expressway. For example, form an area bounded by arterial streets a given distance away from the expressway and obtain the before-and-after results for this area. Clearly, this approach will not be as precise as a full-scale new assignment, treating the section as marginal. This is because an expressway can have influence on travel in the entire metropolitan area and not only in the defined area. However, the bulk of the influence can be expected to obtain in the defined area. Hence, though estimates obtained this way will lose some accuracy, they nevertheless may be useful for planning purposes.

The discussion to this point has been limited to an initial before-situation and an ultimate after situation. (There was some generali-

zation through the consideration of several alternative ultimate after situations.) This is a simplification that skirts important considerations. The simplification was made (a) for ease of exposition and (b) because, in practical situations, budget restraints may limit the analysis to this simplified case. Thus, each alternative considered properly involves a corresponding traffic assignment; for a large network the computations involved can be quite expensive. As a consequence, the computation of a number of traffic assignments could be prohibitively expensive.

TIME CONSIDERATIONS

Conceptually, however, a broader and more realistic approach can be developed. This would involve a whole series of before-and-after situations, starting with an intitial network and adding parts of an expanded network at different points in time. As a consequence, the effect of changes in the system—including increased traffic because of population and income increases—can be handled in a more realistic fashion than the simplified case previously discussed.

This section will be addressed to considering such an approach, assuming away the real world problem of budget limitations.

As a preliminary consideration, some additional comment on capitalization—or discounting—appears in order. An amount of money to be spent or obtained in the future can be discounted—that is, brought back and made equivalent—to an amount in an initial or base year. This can be exhibited as follows. If a dollar today is worth $1.05 a year from now (by way of interest, if it is invested), obviously $1.05 to be obtained a year from now is worth only $1.00 now. Similarly, $1 to be obtained a year from now is worth only $1/$1.05 or $0.95 now. Again, $1 not obtained until five years from now is worth only $1/$(1.05)^5$ or $1/1.0276, which equals $0.784 now ($0.784 is the amount that will compound to $1 if invested at a five percent interest rate). These remarks apply to streams of income and expenditure made over a series of years—the components of the stream are divided by the appropriate factors and made comparable in the present or base year. This discounting process logically should be applied in evaluating a stream of costs and benefits for a series of investments in the highway network.

Assume the following situation prevails with respect to highway

investment. Assume parts of an expressway network are scheduled for different construction dates. A set of expressways (or a single expressway) labeled group I is scheduled to be constructed in 1965. Similarly, group II is to be constructed in 1970, group III in 1975, and group IV in 1980. Then a table such as Table IV can be made up to exhibit expected costs and (implicitly) benefits involved at the time of construction of each expressway.

TABLE IV—EXHIBITION OF EXPRESSWAY CONSTRUCTION COSTS AND TOTAL TRAVEL COSTS OVER TIME

Year	*Vehicle occupants' yearly travel costs under initial system*	*Changes in system*	*Cost of making changes (construction, etc.)*	*Travel cost to vehicle occupants' given changes to date*
1961	T_{1961}			$N_{1961} = T_{1961}$
.	.			
.	.			
.	.			
1964	T_{1964}			$N_{1964} = T_{1964}$
1965	T_{1965}	Add Group I	C_{1965}	N_{1965}
1966	T_{1966}			
.	.			
.	.			
.	.			
1970	T_{1970}	Add Group II	C_{1970}	N_{1970}
.	.			
.	.			
.	.			
1975	T_{1975}	Add Group III	C_{1975}	N_{1975}
.	.			
.	.			
.	.			
1980	T_{1980}	Add Group IV	C_{1980}	N_{1980}
.	.			
.	.			
.	.			
2000	T_{2000}			

In Table IV, there is a column of values labeled T where T represents vehicle occupants' transportation cost in the absence of expressway construction and the associated subscript indicates year. Thus, T_{1961} is total transportation in 1961, and T_{1980} is the transportation cost if no improvements are made. Table IV contains a column of values labeled N where N represents total transportation costs given expressway construction to date.

Then $T_t - N_t$ equals gains in a given year t. For example,

T_{1965}—N_{1965} equals the 1965 gains flowing from the construction of group I. For the years 1961 through 1964, T equals N; that is, there are no gains because no improvements are posited. It should be noted that the values of T and N can change from year to year because of increased vehicle miles of travel reflecting increases in population and income. (In practical work, the values of N and T could be based on traffic assignments obtained for the years in which construction occurs with in-between years obtained by interpolation.) The series of gains resulting equals:

$$(T_{1965}-N_{1965}) + (T_{1966}-N_{1966}) + \ldots + (T_{2005}-N_{2005})$$

This stream of gains can then be discounted to the present. The year 2005 is listed as the terminal date on the basis of the fairly arbitrary assumption that the new network will have a life span of twenty-five years beyond its last improvement.

On the other side of the ledger, the cost series consists of the expenditures involved in the construction of each improvement and logically includes the capitalized value of maintenance. This series, too, can be discounted to the present.

The discounted streams of costs and benefits can now be compared for the given system, and decisions can be based on this comparison.

It might be noted that the choice of life span of twenty-five years beyond the last improvement was made to reflect inherent risks involved in this investment; for example, a transportation development that could make highways obsolete. An alternative to this assumption would be to consider a perpetual stream of benefits flowing from the investment but discounted at the market rate of interest plus a risk component. Costs, on the other hand, would be discounted at the market rate of interest. Thus, costs would be discounted at five percent, while benefits might be discounted at seven percent (with two percent of that rate representing risk).

A scheme similar to that presented here could be used to shed some light on the problem of the optimal sequence of investment. Alternative construction sequencing could be considered; for example, construct group II in 1965, group I in 1970, group IV in 1975, and group III in 1980. Or, construct group I in 1964, group II in 1968, group III in 1972, and group IV in 1976. For these

alternatives compute discounted costs, benefits, and net social profit. Select that plan which yields the maximum profit.

It is apparent that a rather staggering set of alternatives are possible. This set must be limited by some selection scheme prior to using the outlined procedure. Part of this limitation may reflect government policy or administrative rules; for example, if there is an upper limit to available funds and possible construction in a given year.

THE SOURCES OF THE COST-SPEED RELATION

In Table I, vehicle occupant costs are related to speed. The sources of the table entries will be discussed at this point.

Table V presents total costs per vehicle mile related to average speed, enumerates the components of total costs, exhibits savings if a vehicle mile is traveled at forty-five miles an hour instead of a lower speed, and shows time savings as a fraction of total savings.

TABLE V—VEHICLE OCCUPANT COSTS

Average speed	*Time cost per vehicle mile*	*Operating cost*	*Accident cost*	*Total*	*Saving by substituting 45 miles per hour costs for costs of given speed*		
miles per hour			*cents per vehicle mile*		*All*	*Time*	*Time + All*
5	28.60	6.10	9.00	43.70	37.22	25.45	.68
10	14.30	4.62	4.30	23.22	16.74	11.15	.67
11	13.01	4.41	3.80	21.22	14.74	9.86	.67
12	11.87	4.23	3.40	19.50	13.02	8.72	.67
13	11.01	4.09	3.15	18.25	11.77	7.86	.67
14	10.15	3.95	2.90	17.00	10.52	7.00	.67
15	9.58	3.84	2.70	16.12	9.64	6.43	.67
16	9.00	3.72	2.50	15.22	8.74	5.85	.67
17	8.44	3.62	2.30	14.36	7.88	5.29	.67
18	8.01	3.55	2.10	13.66	7.18	4.86	.68
19	7.58	3.48	1.95	13.01	6.53	4.43	.68
20	7.15	3.39	1.80	12.34	5.86	4.00	.68
21	6.86	3.33	1.65	11.84	5.36	3.71	.69
22	6.44	3.28	1.50	11.22	4.74	3.29	.69
23	6.15	3.22	1.40	10.77	4.29	3.00	.70
24	6.00	3.16	1.27	10.43	3.95	2.85	.72
25	5.72	3.12	1.15	9.99	3.51	2.57	.73
30	4.72	2.91	0.80	8.43	1.95	1.57	.81
35	4.15	2.78	0.55	7.48	1.00	1.00	1.00
40	3.58	2.74	0.38	6.70	0.32	0.43	1.34
45	3.15	3.03	0.30	6.48	–	–	–
50	2.86	3.28	0.30	6.44	–	–	–
55	2.57	3.61	0.30	6.48	–	–	–
60	2.43	3.90	0.30	6.63	–	–	–

Components of total costs are time costs, operating costs, and accident costs.

Total Costs: Total costs per vehicle mile decline steadily with speed, reach a minimum of fifty miles per hour, and then increase slightly. Stability of costs within the forty to sixty mile range occurs because operating cost increases balance time cost decreases.

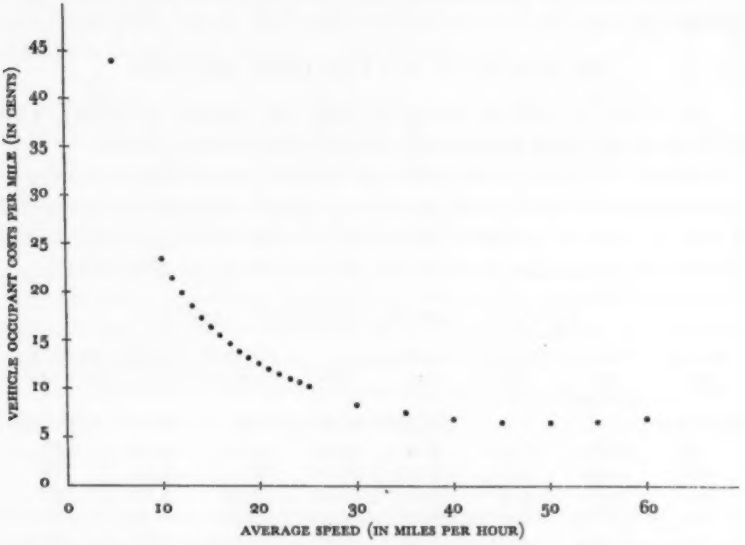


Figure 1. Vehicle Occupant Costs Per Mile Related to Average Speed.

Figure 1 plots total costs against speed; the resultant figure is essentially a hyperbola reflecting the influence of time costs.

Time Costs: Time costs per vehicle were set at $1.43 an hour. This was based on the following considerations. Of total Chicago area vehicle trips in 1956, 14.5 percent were truck trips; 85.5 percent were automobile trips. The value of truck driver time was set at $3 an hour, the going wage rate. For automobile occupants, the value of time was set at $1 an hour for wage earners, since $1 is the minimum wage. It was assumed three-fourths of automobile occupants were wage earners (to account for trips by nonwage earners), yielding 75 cents as the average value of vehicle occupant time. There were 1.56 occupants per automobile, so total time-value

per automobile was $1.17 an hour. Then, weighting truck and automobile hourly value by their respective percentages yielded $1.43.

Time cost related to speed was obtained by taking the reciprocal of speed multiplied by time cost per hour. The reciprocal of speed is the time required to travel one mile. Thus, if speed is twenty miles an hour, time to travel one mile is one-twentieth of an hour. Hence, one-twentieth times $1.43 yields approximately seven cents a mile as time-cost.

Since time-cost is the reciprocal of speed times a constant, plotting it against speed yields a hyperbola. Time-cost is the major component of total cost. Hence, total cost tends to plot as a hyperbola as well.

Clearly, the proper evaluation of time is a most difficult problem; the arbitrary figure used here is open to question. Empirical evidence exists, however, which indicates the value used here is of fairly realistic magnitude.[4]

Operating Costs: Operating costs include fuel, tire, and brake costs. Costs were broken down into running costs, stopping costs, and delay costs. Running speed and fuel consumption were related to average speed using equations developed by May and Wagner.[5] In applying these equations, estimates of number of stops for given average speeds and average stopped time per stop were developed using Chicago data. Data on fuel consumption costs, tire and other operating costs related to running speed were obtained[6] and, in turn, related to average speed.

Costs of stopping were related to approach speed and, in turn, to average speed. Finally, fuel consumption while idling was accounted for, based on an estimate of 0.35 minutes per stop.[7]

Accident Costs: Accident costs can also be related to speed. This

4. Cf., G. P. St. Clair and Nathan Lieder, "Evaluation of Unit Cost of Time and of the Strain-and-Discomfort Costs of Non-Uniform Driving," *Economic Analysis in Highway Programming, Location and Design,* Highway Research Board Special Report 56, Washington, D. C., 1959.

5. Adolf D. May, Jr., and Frederick A. Wagner, Jr., *Quality of Traffic Flow,* Report 1, Michigan State University, March, 1959.

6. K. A. Stonex, "Relation Between the Automobile and the Highway," paper presented at Highway Research Board Meeting, 1954; and American Association of Highway Officials, "Road User Benefit Analysis for Highway Improvement," 1952.

7. A summary of the CATS work on operating costs appears in H. Joseph, "Automobile Operating Costs," *CATS Research News,* November 13, 1959.

is not as obvious in this case as it is for other cost items, but there is empirical evidence to bear this out. Results obtained here are based on a Chicago accident study reported in a previous *Traffic Quarterly* article.[8]

Accident rates, consisting of accidents a million vehicle miles, were computed for arterials and expressways. Rates on arterials were 14.3, and on expressways were 2.8. An initial translation into money costs yielded 0.62 cents a vehicle mile on arterials and 0.13 cents on expressways. However, the evidence of Chicago area insurance rates, plus other evidence, indicated that three times this cost was more appropriate, yielding 1.86 cents a mile on arterials and 0.38 cents on expressways.

Strong evidence also was available which indicated accident rates were highest in the congested parts of the city and decreased with movement toward the suburbs. But as congestion increases, average speed decreases so that a plotting of accident rates and average speed will show an inverse relation. Table IV exhibits this tendency explicitly using data from the Chicago area. Accident rates decrease as speed increases for the observed points.

TABLE—VI ACCIDENT RATES RELATED TO AVERAGE SPEED

Estimated speed *miles per hour*	*Location*	*Accident rate* accidents per million vehicle miles*	*Accident cost cents per vehicle mile*
8	Madison Street in central business district	14.3	5.60
15	Average in central area	2.8	2.70
20	Average on arterials	8.4	1.86
30	Average in outlying areas	21.0	0.80
40	Congress expressway	42.9	0.38

*Refined accident rate, giving intersection accidents a weight of one-half.

It should be noted that this data does not imply that increasing speeds on a given street will reduce accidents. Points on the fitted curve have underlying differences in terms of congestion (and the highest speed point is an expressway observation). It could be that for a given degree of congestion (measured by traffic volume divided by some measure of street capacity) accident rates increase with

8. I. Hoch, "Chicago's Accident Experience on Arterials and Expressways," *Traffic Quarterly*, Vol. XIV, no. 3, July, 1960.

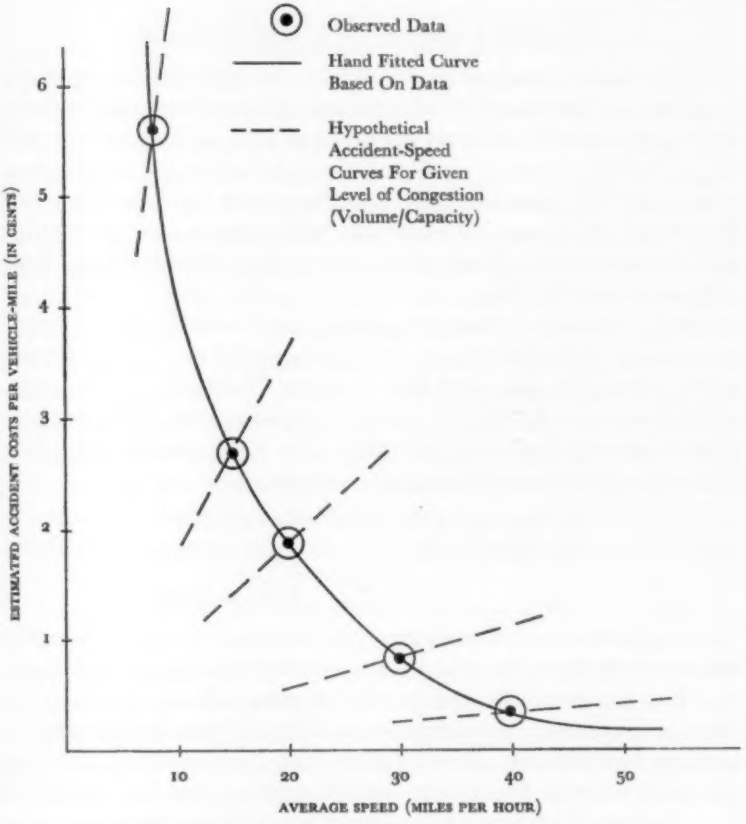


Figure 2. Accident Cost Related to Average Speed.

speed. Figure 2 plots the data of Table VI and fits a curve to the data. This fitted curve was then used in developing the accident cost column of Table V. Figure 2 also exhibits a set of hypothetical curves expressing the possible relation between speed and accident rate if congestion were to be held constant.

There are a number of problem areas where further research

may be fruitful. These areas include (1) estimation of the value of time, (2) interest rates and risk, (3) induced travel by expressways, and (4) preliminary choice between alternatives.

PROBLEM AREAS FOR FURTHER RESEARCH

Time Value Considered at Length: In the artificial example discussed in the first part of this paper, travel costs given a full expressway system in 1980 were on the order of $7.1 million per day and $2.414 billion a year. Travel costs for 1980, assuming no improvements over the present system, were listed as $9 million a day and $3.060 billion a year. (Travel costs here refer to time, operating, and accident costs.) Much of the size of these figures derives from assigning value to time.

Some insight into these magnitudes can be obtained by a rough estimate of 1956 travel costs. Thus, there were 1.5 million vehicle miles in the Chicago study area in 1956. On the basis of average vehicle insurance of $180 a year and operating costs of $300 a year (based on an average 10,000 miles driven at 3 cents a mile), the following 1956 expenditure figure is obtained:

Automobile insurance	$270 million
Operating costs	450 million
	$720 million

The magnitude of these figures can be checked by calculating estimated total money expenditures on transportation (which differs from the previous concept of total costs). Thus, if a figure of $300 a vehicle per year is taken as a measure of vehicle depreciation, parking, fines, licenses, then an additional $450 million is added to the previous total. This yields a total cost to automobile owners of $1.17 billion. This is in scale with estimated total personal transportation expenditures of around ten percent of income. Chicago study area income was estimated as around $14 billion in 1956, yielding about $1.4 billion for transportation. The difference between $1.17 and $1.4 billion can be ascribed to mass transit, rail and plane fare, etc.

The 1956 value of time spent driving at $1.43 an hour (given 10,000 miles per vehicle, 1.5 million vehicles, and an average twenty miles an hour) yields a time cost in 1956 of $1.07 billion.

Travel costs, restricted to time, operating and accident costs, then equal $1.8 billion in 1956.

Two points may be noted on the basis of these estimates. First, the 1980 hypothetical figures are fairly well in line with 1956 actual figures allowing for growth in travel with population and income increases. Second, time cost is a large magnitude and is close to total money expenditures on transportation ($1.07 billion versus $1.4 billion). Time costs amount to sixty percent of the total travel cost (time, operating, and accident costs).

It may be that the value of time used here is an overstatement (though empirical work tends to confirm this magnitude). On the other hand, it does not seem reasonable to assign a zero value to time. (If a zero value were assigned to time, social profit, in the artificial example discussed earlier, would drop from $7.0 billion to $1.6 billion.) Additional experience with driver behavior (on toll roads, for example) may shed more light on vehicle occupants' evaluation of time.[9]

Interest Rates and Risk: It has been suggested in this article that interest rates used in evaluation ought to be set at the market rate of interest so that public and private returns on investment are equalized. The market interest rate was treated as equal to five percent.

In evaluation of benefits, some provision should be made for risk. This can be done by setting an arbitrary expected life for an expressway (for example, twenty-five years) or by using an interest rate containing a risk component (for example, seven percent).

The appropriate value for the risk component is open to question. It might be negative since the going market interest rate contains some risk component, and it is possible the risk of expressway construction is below that of private investment. It has been argued that using an interest rate of seven percent (or more) is "conservative" because it is likely to yield benefit estimates which are on the low side. This course was advised here, but the question certainly is open to additional inquiry.

As previously noted, adverse travel is accounted for by the outlined procedures. However, there may be some questions about travel the expressway itself induces. For example, the construction

9. This would be along the lines of the work of St. Clair and Lieder, *op. cit.*

of expressways may cause more travel to occur because (1) some people change their mode of travel from transit use to driving, (2) there is some effect on total population with additional people being attracted to the metropolitan area given a new expressway, and (3) there is a change in the community's locational pattern as a consequence of the expressway.

If the first item does in fact occur, that is, if there is a change in mode because of the construction of the expressway, this can be incorporated in the analysis. (The change referred to here is independent of mode changes reflecting increased income.) Costs of ex-transit passengers, before and after their change in mode of travel, can be calculated and incorporated into the evaluation procedure.

The same type of argument can be developed for the other items, although it is difficult to gauge such effects. Conceptually, at least, such movements could be incorporated into the assignment procedure.

It might be noted that an expressway *system* tends to yield a fairly uniform distribution of population, given distance from the city center; and there is much less of a localizing effect than that occurring for rail transit systems in the past.[10]

Under this reasoning, alternative expressway systems might differ very little in their impact on size and location of population. Again, other factors might have much greater effects on growth once a certain minimum network exists. These factors include economic and social factors such as growth in real income and distance from city center.

At any rate, the feedback effects of expressway construction might merit additional investigation.

Stating of Alternatives: Procedures outlined here begin with a given set of alternative networks. This assumes only a limited number of cases are under consideration. However, nothing has been said about the means of selecting from among a very large (or

10. Cf., John R. Hamburg, "Land Use Projections for Predicting Future Traffic," *Trip Characteristics and Traffic Assignment*, Highway Research Board Bulletin 224, Washington, D. C., 1959.

possibly infinite) set of alternatives the particular alternatives to be considered. Such selection involves the skills of the engineer and planner and probably comprises the major part of benefit-cost analysis in concrete, practical situations.

As an example, consider the sequencing problem mentioned previously. Assume there are four expressways to be constructed and the problem posed is: What is the optimum order and time sequence for construction; that is, in what year should each expressway be constructed?

Excluding the question of date of construction, there are twenty-four possible combinations of four expressways. If the construction dates are allowed to vary, the number of possible combinations can quickly become formidable. Thus, for a given ordering of four expressways, if there is a twenty-year time period under consideration, with four years containing an expressway start and sixteen not containing a start, then there are 4,845 possible time sequences.[11]

Hence, for 24 orderings there are 116,280 possible sequences. The introduction of locational variability would further greatly increase the number of alternatives.

The introduction of additional constraints may limit the problem, and it is possible that some sort of routinized mathematical device may be developed to restrict the area of choice. However, in the present state of the art (and given the present costs of computation), a great deal of the essential preliminary choice among alternatives must be based on the engineer's and planner's special knowledge, skill, and judgment.

The consideration of the widest range of alternatives and selection of those to be evaluated may thus be the most important area for further research in this field.

11. Based on the combination formula $\frac{n}{n_1 \; n_2}$ where $n=20$, $n_1=16$, and $n_2=4$.

The Relation of Mass Transportation To Total Transportation in Detroit

ALGER F. MALO

Mr. Malo is Director of the Department of Streets and Traffic of Detroit, Michigan. Formerly he was City Traffic Engineer. From 1933 to 1943, he was an engineer with the Michigan State Highway Department, serving as Assistant Engineer of Road Design, later in charge of the Traffic Engineering Division, and subsequently in charge of the Road Design Division. From 1944 to 1948, he was Detroit's Expressway Engineer, Consulting Engineer, and Safety Engineer consecutively. Mr. Malo holds an Architectural Engineering degree from the University of Detroit. He later did graduate work at the Yale University Bureau of Highway Traffic.

IN March, 1956, the final report on the Detroit Metropolitan Area Traffic Study was published. This study of traffic movement encompassed Detroit and the surrounding region, an area containing three million people, nearly a million vehicles, and 5,700,000 person-trips.

On an average weekday, 880,000 or seventeen percent of the trips were made on mass transit vehicles. Twenty-five percent of all the workers in the area and fifty percent of all persons traveling to the central business district used public transit. The characteristics of transit rider travel were considered important because of the downward trend of transit usage between 1948 and 1954.

The number of passengers on the Detroit Department of Street Railways declined from 420 million annual revenue passengers to approximately 232 million or a reduction of about forty-three percent. Bringing this up to date, the annual revenue passengers in 1960 were a little over 130 million, or a further decline from 1954 of forty-four percent.

While this decline in mass transit patronage was taking place, automobile ownership and vehicle usage increased considerably. Motor car registration in Wayne County increased from 1,022,000 in 1954 to 1,200,000 in 1960 or an over-all increase of 11.8 percent. This compares with the over-all decrease in transit use previously mentioned of forty-four percent. (Figures 1 and 2)

Biennial cordon counts of the central business district of Detroit made by the Department of Streets and Traffic have indicated a similar trend for persons and vehicles entering the Central Business District during the twelve-hour period from 7 a.m. to 7 p.m. on a typical weekday. In 1948, some 435,000 persons entered the Central Business District, of which 168,000 were in private automobiles.

In 1960, only 343,000 entered but 223,000 were in private automobiles or taxis. During the same period, the total entering by mass transit declined from 267,000 to 119,000 or fifty-five percent. During 1960, only thirty-five percent of all persons traveling to the Central Business District used public transit. It can be seen that the number of people entering the Central Business District during this period declined twelve percent, the number of private vehicles entering increased thirty percent.

DETROIT'S MASS TRANSPORTATION

Mass transportation in the Detroit area consists primarily of a motor-bus system, owned and operated by the City of Detroit. Suburban bus lines serve the surrounding communities of Wyandotte, Trenton, Royal Oak, Birmingham, Pontiac, East Detroit, Roseville, Mt. Clemens, the Grosse Pointes, and numerous other small centers of population. All of these communities are within a thirty-mile radius of Detroit. The Grand Trunk Railroad furnishes rail commuter service between Detroit and the north Woodward suburban areas as far as Pontiac. The New York Central and the Chesapeake and Ohio Railroads serving Ann Arbor, Plymouth, and Lansing carry commuters to Detroit on their regular passenger service, but the number is insignificant.

THE DEPARTMENT OF STREET RAILWAYS

The relative importance of these mass transportation systems is revealed by the central business district cordon count. In 1960, the Detroit department of street railways carried approximately 103,000 passengers into the central business district on an average weekday; at the same time, suburban busses carried 17,000 passengers into the district, and about 3,000 entered by suburban rail.

The Detroit Department of Street Railways has been municipally owned since 1925 when it purchased the privately owned

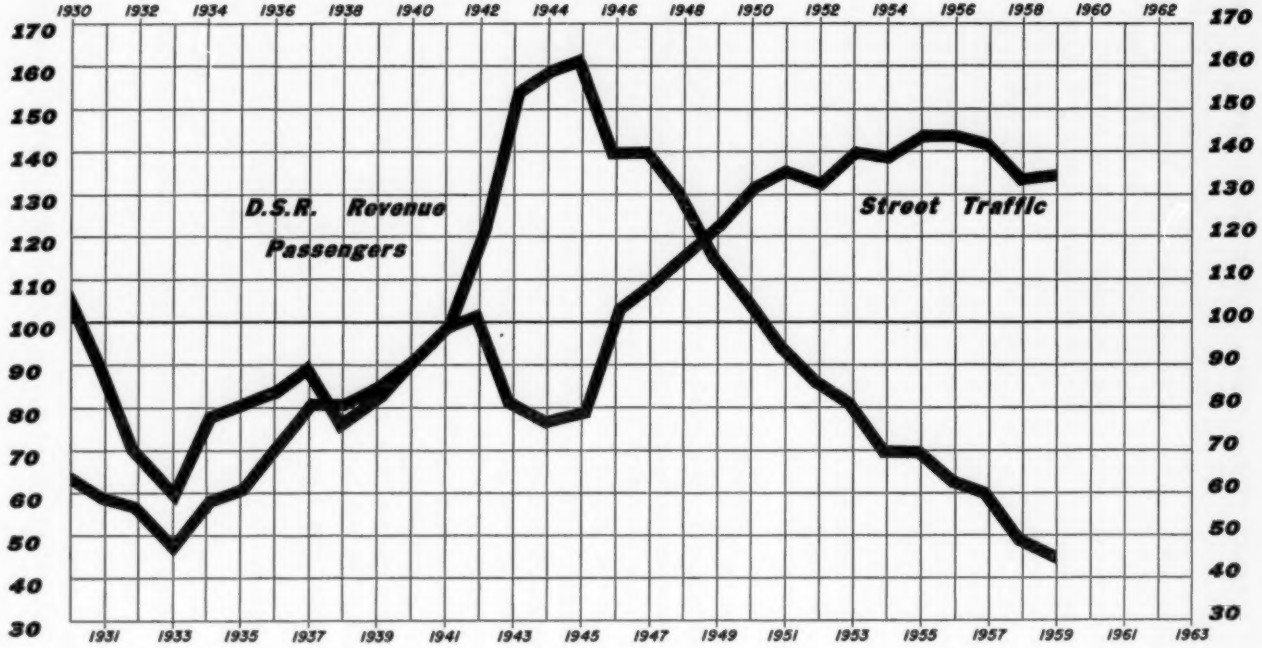


Figure 1. Index of Detroit Traffic.

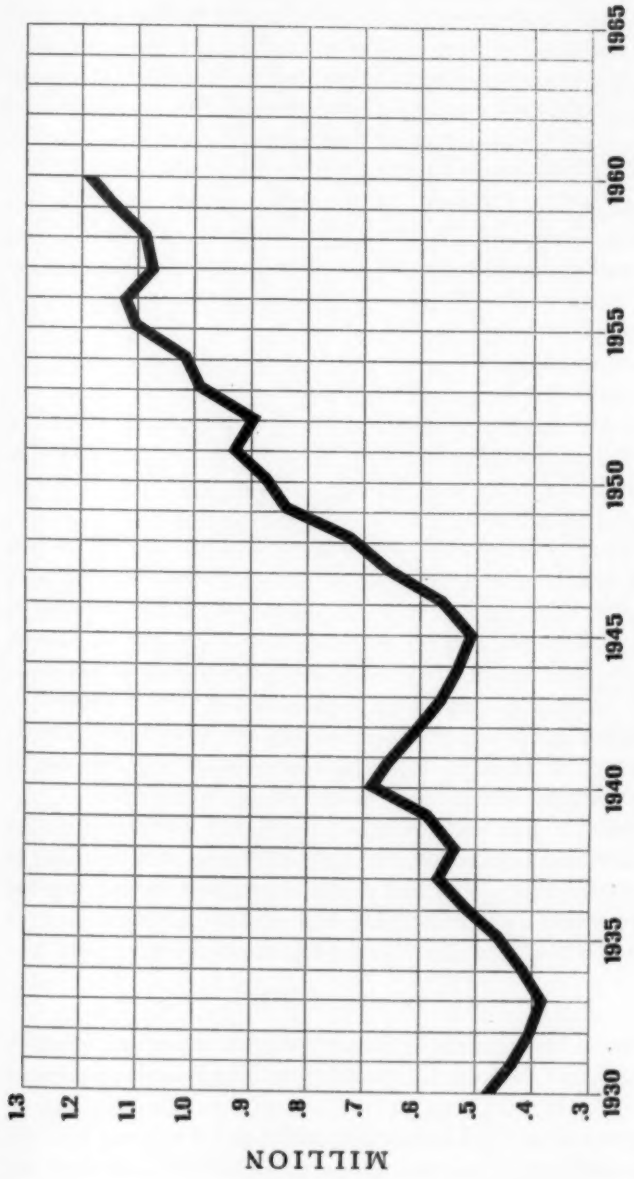


Figure 2. Wayne County Vehicle Registration.

Detroit United Railway. The Charter of Detroit, under which this system operates, instructed the Board of Street Railway Commissioners to make the system exclusive as soon as it was practical.

The only other competition was the Detroit Motor Bus Company later purchased by the municipal system. Suburban operators may carry passengers between Detroit and suburban communities, but may not serve passengers traveling within the city limits.

Under the City Charter, the municipal system must operate like a private company. Its rate of fare must be sufficient to pay operating and maintenance expenses, fixed charges, bond amortizations, and taxes on the physical property of the entire system, the same as though privately owned.

The municipal system at one time consisted primarily of 910 streetcars operating on 426.46 route miles of fixed rail. Motor bus lines eventually were established and as their popularity increased they began to supplement the fixed rail system. In 1947, after the abandonment of some minor rail lines, the Grand River streetcar line, a major facility, was replaced with trolley coaches.

Later, the crosstown line operating on Warren and Forest was also converted to trolley coaches. The last streetcar lines were abandoned in 1956, so that with the exception of the two special trolley-coach lines the system now operates with gas- or diesel-motor busses. The system today, including the trolley-coach lines, consists of 1,004 gas- and diesel-motor coaches plus seventy-two trolley-coaches operating on sixty-six regular routes and fifteen express routes, a total of 1,442.74 route miles. Four hundred thousand passengers are carried on an average weekday.

In addition to operating within Detroit, the Charter provides that the municipal system may serve the suburban areas within ten miles of the city limits. Over and above the regular service, express service is operated during the peak hours on fifteen lines. Four of these utilize Detroit's expressways for a portion of their route.

RAPID TRANSIT STUDIES

The Detroit Department of Street Railways is administered by the Board of Street Railway Commissioners. The Board was created in 1913 as a Charter department by a vote of the electorate, having as an objective municipal ownership of the street railway system. It was not until this time that urban transportation assumed an important role in Detroit. (Figure 3)

Figure 3. Detroit Department of Street Railways.

Until the turn of the century, Detroit had not experienced a rapid enough increase in area and population to raise serious questions regarding its mass transportation. In 1900, the federal census listed a total of 285,700 persons living within the 28.35 square miles that comprised Detroit. By 1914, however, Detroit had grown to 41.76 square miles and 595,000 inhabitants. Then, rapid transit received its first special attention.

The first official report on rapid transit in Detroit was that of the Street Railway Commissioners in 1914. This and the report of consulting engineers in 1915 were received by the Common Council, but no definite action was taken. A second consultants' report, submitted in December, 1917, recommending a rapid transit system was shelved because of the plans for acquisition of the privately owned street railway lines and because of World War I activities. As stated in the foregoing, the acquisition of the privately owned lines took place in 1925. By then, the area of the City had increased to 119 square miles with a population of 1,246,000.

In 1922, the mayor appointed a rapid transit commission. By vote of the electorate this commission was established under Detroit's charter. One of the first actions of this commission was to authorize a study of vehicular traffic in the city. As a result of this study and in collaboration with other city departments, the rapid transit commission recommended a system of major thoroughfares within the city (formally adopted by the common council on April 4, 1925) as the master plan for Detroit. Subsequently, on December 14, 1925, the superhighway commissions of Wayne, Oakland, and Macomb counties also adopted a master plan of superhighways for the tri-county area, principally as an extension of the Detroit Master Plan.

This master plan provided a radial and grid system of superhighways extending to a radius of fifteen miles from the city hall. There was provision for twenty superhighways, 204-feet wide, at three-mile intervals, aggregating 240 route miles. The 204-foot right-of-way width included two four-lane roadways on each side of a central space of eighty-four feet for the exclusive use of four-track rapid transit lines on rails with tree and shrub planting to screen it. Although some of the 204-foot superhighways were within the city limits, most of the main thoroughfares were to be widened to a minimum width of only 120 feet.

Secondary thoroughfares were planned for widening to eighty-six feet. The width of 120 feet was recommended to provide for full four-track local and express underground development. The eventual surface development resulted in a ninety-foot pavement with two streetcar tracks in the center.

The first master plan of highways was adopted upon the recommendation of the rapid transit commission. The three counties involved and the City of Detroit developed the plan to the extent that this system of highways has become the backbone of the surface vehicular transportation system of the area. Southfield and James Couzens Highways, two of the original 204-foot highways, are now being converted to fully controlled access highways with little additional right-of-way acquisition.

Portions of others are to be converted to full freeways either on the existing 204-foot width or by the acquisition of additional right-of-way. Many miles of the 204-foot system are fully developed as divided eight-lane highways with a landscaped center divider.

Actually, the rapid transit commission was established for the purpose of developing, maintaining, and operating a rapid transit system in tunnel, subway, elevated, or any combination of such systems. Since this charter amendment was established, at least twelve reports were prepared by the rapid transit commission or consultants recommending some type of rapid transit for Detroit. No system has ever been adopted or financed.

The most recent report was submitted to the Mayor and to the Common Council by the rapid transit commission in 1958. This report recommended a monorail rapid transit network for the Detroit metropolitan area at a total cost of $255 million. This report was submitted to a committee of city department heads for review and was subsequently shelved along with the numerous other rapid transit reports. Such a project could not be financed out of revenue, and the taxpayers have not indicated their willingness to subsidize a rapid transit system.

TRANSIT PLANNING

The department of street railways, operating under the stipulation that it shall live within its revenues, has been generally well managed, but, of necessity, conservative. Revenue had begun to decline prior to World War II. Recognizing the trend, the depart-

ment began planning for the future immediately following the end of the war and the lifting of the restriction on the use of gasoline.

Planners in the department recognized the fact that the automobile would now be a greater competitor than ever before and that plans should be prepared to modernize the system to operate as economically as possible. Future projections called for the eventual abandonment of all streetcar lines; the establishment of express operation on proposed expressways to furnish fast service from one section of the city to another; the provision of off-street loading facilities in the central business district, and the revision of many routes to provide more efficient and economical service.

The study of the transportation situation in Detroit resulted in the following excellent analysis:

> Of fundamental importance in projecting the plan for transportation for Detroit is the pronounced and vigorous trend of decentralization. There is a consistent tendency for both industries and residences to move outward from the inner area of the city. Insofar as public transportation is concerned, this movement constitutes many difficulties. Longer transportation lines are necessary to reach the population, and, because of low densities accompanying such decentralization, the department of street railways has been forced to employ much more flexible units than those provided by fixed rail operations.
>
> The total population to be served is vitally important. This raises questions as to what are the possibilities for population growth in the city. Very exhaustive studies conducted by the city plan commission have indicated that the opportunities or potentialities for increased population within the City are very definitely limited. Available area for development of residential areas is an amazingly low percentage of the total city area. Moreover, the same limitation exists with reference to the expansion of industries within the City. It appears, therefore, that any expansion of population which might be located within the service area of the transportation system would be outside of Detroit.
>
> Further expansion of the service area in the future would tend to accent the difficulties as related to public transportation, particularly with reference to lower and lower densities. It is evident, in view of the trends of development of the Detroit area, that the transportation system must possess the utmost flexibility rather than the inflexibility of heavy, fixed rail operations. Due to the ever increasing outward movement of the traffic load on the public transportation system, the need for express movements is greatly emphasized.

The report recognized the programs of other agencies and special considerations were given to the studies being made by the city plan commission. The following, also quoted from the report, is important:

> In the developing of the department's plans, careful consideration was given to the studies of the city plan commission. After a careful review of the studies of the Plan Commission, particularly with reference to the lessening population in the inner Boulevard area, and the lessened densities which would prevail throughout the city; the restricted potentialities of the expansion of industries within the area; provision for enlarged recreational areas, and displacement of families resulting therefrom; together with displacement of families which will be caused by the expressway program, and many other factors, it was clearly indicated that the plan for public transportation should be patterned largely upon the use of the free-wheeling type of vehicles; that is, motor or electrically operated coaches.

Conclusions by the engineers in this report have been substantiated by developments in Detroit. The 1960 census indicated that Detroit's population declined from 1,837,000 in 1950 to 1,662,000 or 175,000 persons; on the other hand, the increase in population in the adjacent suburban communities has been as high as 199 percent. (Figure 4)

Business and industry have decentralized and shopping centers and industrial developments have been established beyond the city limits. The displacement of families by the construction of expressways and the urban renewal plans have reduced population densities and changed traffic patterns in many areas. The need for transportation flexibility has been demonstrated and the original fixed rail operation would not serve today's needs.

The plan for extensive off-street terminals in the central business district never materialized. Instead of congesting the streets in the central business district as was anticipated by some planners, the expressways and the very important accompanying street widening and off-street parking programs have relieved the traffic situation in the central business district. Transit vehicles enter and leave the central business district with little or no traffic difficulty. Although off-street loading and unloading (as demonstrated at two locations now in use in the Central Business District) would be more efficient, busses can still load and unload at the curb and give satisfactory service.

While the rapid transit commission was preparing reports for underground, surface, and elevated rail transit systems, the city, county, and state highway authorities were going ahead with the development of the surface street system as recommended in the 1925 master plan. Highway Commissioner Grover C. Dillman entered into an agreement with the City of Detroit sometime around 1930 for the widening of Gratiot, Woodward, and Michigan Avenues three main traffic arteries in Detroit.

STREET AND HIGHWAY PLANNING

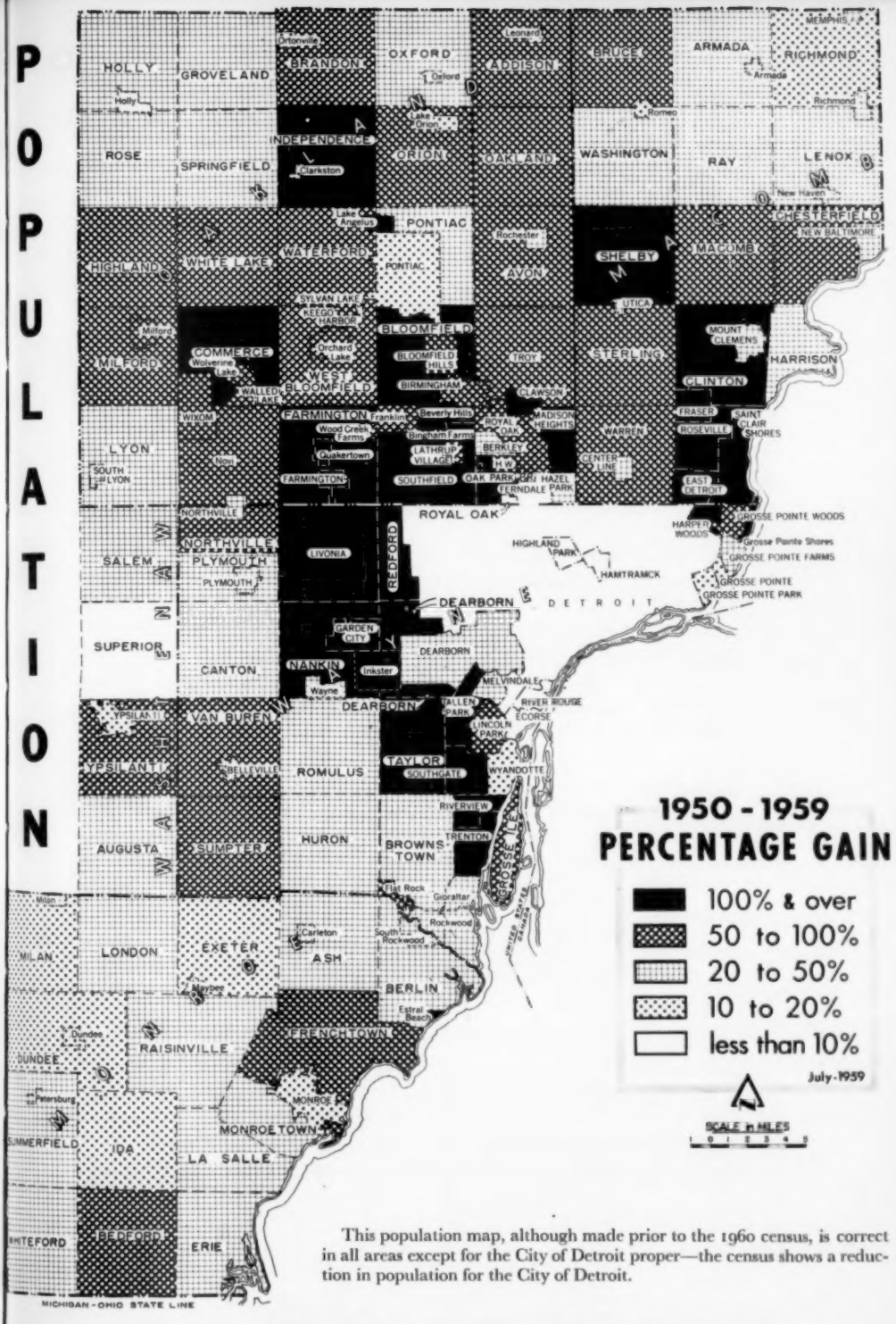
This plan called for the widening of these streets from their approximate sixty-foot right-of-way to 120-foot right-of-way; the pavement width was to be ninety feet with two-way streetcar operation in the center. The succeeding highway commissioner Murray D. Van Wagoner carried out this agreement and the widening of these streets was finally completed by 1940.

In the meantime, the state highway department was also recognizing the need for a new type of highway facility and began preparing plans for a system of limited access highways in the Detroit area. In spite of gas rationing during World War II, it became obvious that high-type highway facilities were required to move vehicles and goods about the community. This led to the construction of the Willow Run highway system leading from the war-born Willow Run Bomber Plant to the city limits of Detroit near Wyoming and Michigan.

Plans were then prepared for completing this highway across Detroit and eventually to Port Huron at a connection with the Blue Water International Bridge. About this time, the Wayne County Road Commission began preparing plans for a limited access highway which would connect the central business district with James Couzens Highway in the northwest residential area of Detroit.

CENTER MALLS FOR RAPID TRANSIT

In February, 1945, a report, "Detroit Expressway and Transit System," prepared by consulting engineers, was submitted to city officials. In the report was a proposal that rapid transit rail operation be incorporated in the center mall of the proposed extension of the Willow Run Expressway across Detroit. (This highway now



This population map, although made prior to the 1960 census, is correct in all areas except for the City of Detroit proper—the census shows a reduction in population for the City of Detroit.

Figure 4. Detroit Metropolitan Area—Regional Planning Commission.

completed, locally known as the Edsel Ford Expressway, is part of Interstate 94.) This proposal was similar to the plans of the rapid transit commission as visualized in the 1925 master plan. (To date, none of the center malls included in the original plans have ever been developed for use as a rapid-transit-use facility.)

Since the department of street railways was operating the transit system within the city, it was requested to study the proposal for a center mall train operation and to submit a report on the feasibility of such a plan.

A thorough study was made of this proposal by D.S.R. planners and it was determined that the project was not feasible. Some of their conclusions give an indication of the reasons why Detroit has never built a rail rapid-transit system. For example, they stated the following:

> The most optimistic estimates of traffic, now or in the foreseeable future, do not warrant a service of this type in this location. The consultants' proposal was based on an estimated load of 650,000 persons per day and a maximum load of 15,000 passengers at maximum hours and at maximum load points. This estimate is nearly five times the load determined by our studies. Our survey determined that 131,000 persons—not 650,000—per average weekday would use the facility. The maximum hourly demand at the point of maximum load on the line would be 3,338 persons an hour—not 15,000 persons.
>
> It is inconceivable that traffic in this location would attain the volume upon which the project was based. For comparison, the combined present load on all crosstown lines is 250,000 passengers per average weekday. The two heaviest lines in the city, Woodward Avenue and Grand River, carry 160,000 and 100,000 passengers daily, respectively.

A few of the reasons given for not being able to build up loads on such a facility to the extent that would justify the service proposed are as follows:

> No area of high population density appropriate to this type of facility exists anywhere along the route. No widely separated areas of concentration of population and concentrated or compact areas of destination exist to necessitate a rapid transit rail operation.
>
> The peak hour load is 3,338 passengers and the base load is about 400 passengers per hour, or about one-eighth of the peak load. This would

necessitate very infrequent service during the day and further decrease the inducement to use the facility.

They concluded their report with the following statement:

> The service requirements on this route would be more satisfactorily and more economically provided by rapid transit bus operation. Based on the estimated traffic demand, forty (40) large capacity busses recommended by the consultants for this type of service would amply serve the peak-hour demand at the maximum load point on the route. Ample capacity could be provided for any reasonably anticipated increased demand without interference with normal use of the highway. It would appear unwise to ignore the possibilities of this superior service afforded by the highway.

Included, also, in the report was the fact that operation would incur an annual deficit amounting to approximately one and a half million dollars per year. As a result of the findings of this report, the project was dropped from consideration and the Edsel Ford Expressway (Willow Run) was built without provision for a center mall rapid-transit operation.

The 1945 consultants' report recommended an ultimate rapid transit system providing for subway operations in the major arteries but indicated that certain portions of the route should be constructed in the center of the projected express highways. The report also recommended a start on the over-all subway plan by the construction of downtown subways.

These downtown subways extended from one-half to three-quarters of a mile from the center of the downtown district and were to be used by trolley bus lines and streetcar lines until such time as the extensions of the subways to employ train operations would be required.

In 1947, the department of street railways prepared an estimated cost of rapid transit facilities based on the 1945 report. These estimates were made especially to determine whether a Woodward Avenue rapid transit line should be built and whether the proposed Grand River Expressway should be planned to include a center mall for rapid transit similar to that proposed for the Edsel Ford Expressway.

The study concluded that for the Woodward Avenue line, the total cost in excess of operating revenues would be $4,800,000 an-

nually; for the Grand River Avenue line, the total cost in excess of revenue would be $6,000,000 annually. As a result, plans for the Woodward Avenue subway rapid transit line were abandoned, and the Grand River Expressway, now in the planning stage, will not include a center mall for future rapid transit operation.

POPULATION DENSITY AND LAND USE

It is not difficult to understand the validity of these conclusions when the characteristics of Detroit are considered. The population density of the city is only 11,500 persons a square mile as compared with a population density in Manhattan of 80,852 persons per square mile and in all of the other boroughs of New York, 25,200 persons a square mile. Detroit is primarily a city of private dwellings and does not have large apartment districts similar to Chicago and New York. There are no large centers of origin and destination as are necessary to support high-volume mass transit facilities.

Even before the decentralization trend began, Detroit's industry was spread on a belt from Dearborn on the far southwest across the city through the so-called Milwaukee Junction, and Hamtramck areas and thence to the East side industrial area along Conner Avenue. The office worker population was decentralized early when the huge General Motors office building and the Fisher Building were built three miles north of the downtown area in the so-called New Center Area. (Figure 5)

Shopping centers located in the outlying areas and in the suburbs beyond the city limits have spread shopping destinations far and wide. Rail rapid transit systems are capable of moving people at the rate of 15,000 to 30,000 passengers per hour. Studies indicate that nowhere in Detroit is there need for moving any such large volumes from one destination to the other in any hourly period. In the morning peak hour between 7:30 and 8:30, a total of only 60,000 persons enter the central business district (the area of greatest concentration) on all arteries including the John C. Lodge Expressway from all areas of the city and suburbs and in all types of transportation.

The following table shows how riders in public and private vehicles disperse from the central business district on the main arteries and the John Lodge Expressway. This table shows the

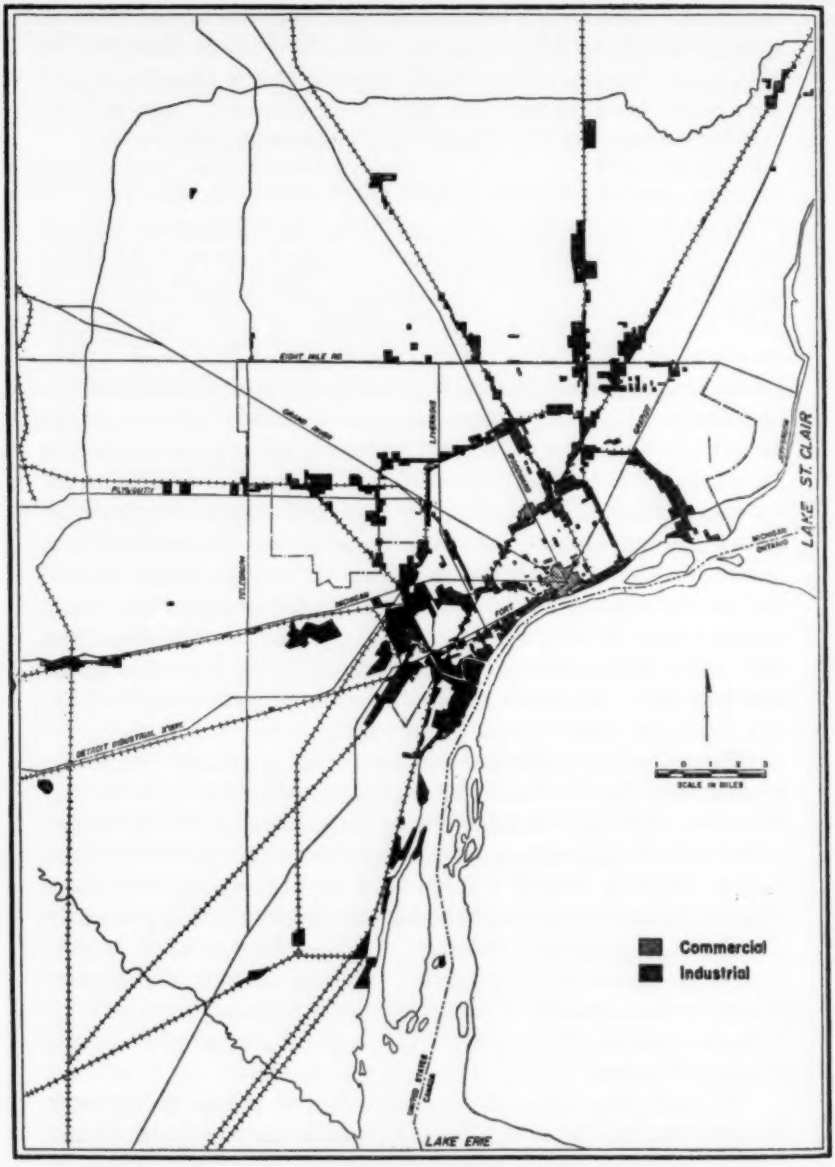


Figure 5. Commercial and Industrial Land Use—Detroit Area.

number of riders leaving the central business district in the maximum hour and in the 12-hour period from 7 a.m. to 7 p.m. in private auto and taxi, in public transit and the total on each artery:

PERSONS LEAVING CENTRAL BUSINESS DISTRICT

		Private Autos & Taxis		*Public Transit*		*Total*	
Artery	*Direction*	*12-Hr.*	*Max. Hr.*	*12-Hr.*	*Max. Hr.*	*12-Hr.*	*Max. Hr.*
Fort	SE	12,758	2468	6136	1347	18,893	3815
Michigan	W	11,764	2401	9910	2300	21,674	4701
Gd. River	NW	12,322	3148	9994	2200	22,316	5348
Woodward	N	12,550	2102	14,270	3379	26,592	5481
Gratiot	NE	21,786	4901	17,229	4787	39,015	9688
Jefferson	E	22,248	4755	10,343	2472	32,591	7227
Lodge Xway	NW	48,082	6558	3718	1179	51,800	7737

DETROIT'S TRANSPORTATION PLAN

The transportation plan for the City of Detroit is based on an all-highway system with rapid transit as required being furnished by busses operating over the expressways. At present, the Edsel Ford Expressway and the major portion of the John C. Lodge, both limited access facilities totalling twenty-four miles, are completed within the City of Detroit. The Chrysler Expressway, Southfield Expressway, and the Lodge extension are presently under construction.

In the planning stages are the Jeffries (Grand River) Expressway and the Fisher (Fort-Vernor) Expressway. These are all to be completed or under contract by 1967 calling for a sixty-mile system within the city limits. The 1953 Origin-Destination Survey calls for an eventual 120-mile system within the city limits and a 260-mile system in the Detroit region. (Figure 6)

The present major street system consists of the main arterials such as Jefferson, Gratiot, Woodward, Grand River, Michigan, and Fort Street; a limited one-way street system of sixty miles; and the major mile streets comprising a total arterial street system of 600 miles. The major arterials entering the central business district vary in width from seventy-two feet to ninety feet. All have center left-turn lanes and carry three or four moving lanes in each direction. All are controlled by completely flexible traffic signal

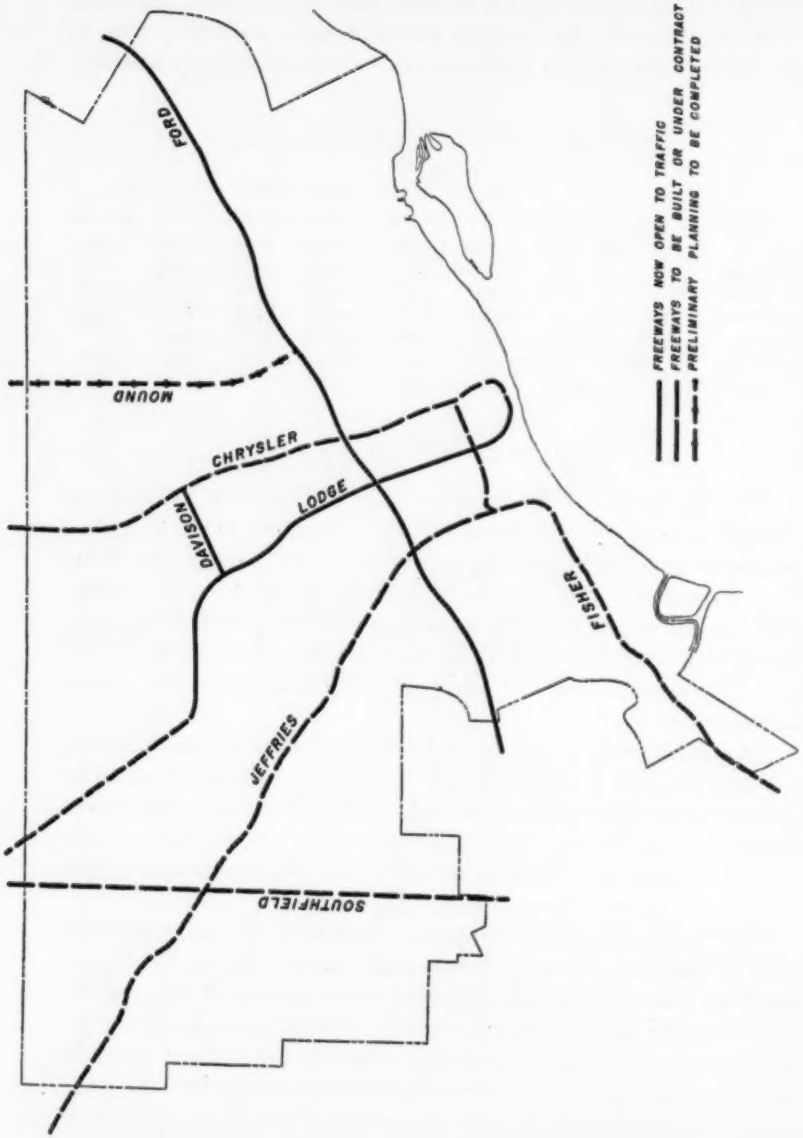


Figure 6. Detroit Ten-Year Freeway Program.

systems which provide excellent movement in the peak hours in the direction of rush-hour traffic. The entire central business district is similarly controlled favoring inbound traffic in the morning and outbound traffic in the afternoon.

The major arterials all carry daily traffic volumes of 40,000 to 50,000 vehicles. Peak hours vary from 2,400 vehicles outbound on three lanes on Fort Street to 3,600 vehicles on the four outbound lanes of Grand River. (Grand River's center left-turn lane becomes a reversible lane during the peak hours with all left turns prohibited.)

Practically the entire length of all major arterial streets has morning and afternoon rush-hour parking prohibitions which are

COMPARATIVE TRAVEL TIME
BUS AND PRIVATE CAR—INBOUND

Street	*Date*	*Time of Run*	*From – To*	*Miles*	*Elapsed Time*		*Average Speed mph*
					min.	*sec.*	
Jefferson E.							
A. Car	Tuesday	7:52 am	Griswold–City Limits	7.1	15	45	25.5
B. Bus	11–15–60	7:52 am			28	00	14.3
A. Car	Friday	7:49 am			15	00	26.8
B. Bus	11–18–60	7:48 am			26	00	15.5
Gratiot							
A. Car	Tuesday	7:06 am	Woodward–Eight Mile	9.6	22	00	26.1
B. Bus	11–15–60	7:06 am			37	00	15.6
A. Car	Wednesday	7:17 am			25	00	23.0
B. Bus	11–16–60	7:17 am			42	00	13.7
Fort W.							
A. Car	Tuesday	7:37 am	Woodward–Outer Drive	8.5	27	00	18.9
B. Bus	11–15–60	7:37 am			35	00	14.6
A. Car	Thursday	7:47 am			22	00	23.1
B. Bus	11–17–60	7:48 am			31	00	16.9
Woodward							
A. Car	Wednesday	7:28 am	Jefferson–Fair Grounds	8.9	24	00	22.2
B. Bus	11–16–60	7:28 am			40	00	14.0
A. Car	Thursday	7:24 am			23	00	23.2
B. Bus	11–17–60	7:24 am			38	00	14.0
Grand River							
A. Car	Wednesday	7:28 am	7 Mile–Capital Park	14.5	36	00	24.2
B. Bus	11–16–60	7:27 am			65	00	13.4
A. Car	Thursday	7:29 am			38	00	22.9
B. Bus	11–17–60	7:29 am			61	00	14.3
Michigan							
A. Car	Wednesday	7:44 am	Wyoming–Woodward	6.2	17.00		21.9
B. Bus	11–16–60	7:44 am			26	00	14.3
A. Car	Thursday	7:40 am			14	00	26.8
B. Bus	11–17–60	7:38 am			28	00	13.3

strictly enforced. This serves the same purpose as exclusive curb lanes for busses only as now used on some streets in other cities. In fact, the D.S.R. prefers this to exclusive lanes because they feel such a system might tend to limit their operation to a single lane which would slow their operations.

COMPARATIVE TRAVEL TIME
BUS AND PRIVATE CAR—OUTBOUND

Street	*Date*	*Time of Run*	*From – To*	*Miles*	*Elapsed Time*		*Average Speed mph*
					min.	*sec.*	
Jefferson E.							
A. Car	Monday	4:33 pm	Griswold–City Limits	7.1	22.	00	19.7
B. Bus	11–14–60	4:32 pm			36	00	11.8
A. Car	Tuesday	5:07 pm			19	00	22.4
B. Bus	11–15–60	5:06 pm			31	00	13.7
Gratiot							
A. Car	Monday	4:32 pm	Woodward–Eight Mile	9.6	23	00	25.0
B. Bus	11–14–60	4:32 pm			34	00	16.9
A. Car	Tuesday	4:32 pm			23	00	25.0
B. Bus	11–15–60	4:32 pm			35	00	16.5
A. Car	Friday	5:02 pm			26	00	22.2
B. Bus	11–18–60	5:01 pm			41	00	14.0
Fort W.							
A. Car	Monday	4:30 pm	Woodward–Outer Drive	8.5	32	30	16.0
B. Bus	11–14–60	4:30 pm			38	30	13.6
A. Car	Thursday	5:03 pm			23	00	22.2
B. Bus	11–17–60	5:03 pm			34	30	14.8
Woodward							
A. Car	Monday	4:30 pm	Jefferson–Fair Grounds	8.9	22	00	24.3
B. Bus	11–14–60	4:30 pm			41	00	13.0
A. Car	Wednesday	4:31 pm			26	00	20.5
B. Bus	11–16–60	4:31 pm			44	00	12.1
A. Car	Thursday	5:03 pm			27	00	19.8
B. Bus	11–17–60	5:02 pm			45	00	11.5
Grand River							
A. Car	Monday	4:33 pm	Capitol Park–7 Mile	14.5	39	00	22.3
B. Bus	11–14–60	4:33 pm			67	00	12.9
A. Car	Wednesday	4:33 pm			34	00	25.6
B. Bus	11–16–60	4:33 pm			62	00	14.0
A. Car	Thursday	5:10 pm			40	00	24.7
B. Bus	11–17–60	5:08 pm			63	00	14.3
Michigan							
A. Car	Monday	4:32 pm	Woodward–Wyoming	6.2	14	00	26.8
B. Bus	11–14–60	4:31 pm			25	00	14.8
A. Car	Wednesday	4:415 pm			16	30	22.6
B. Bus	11–16–60	4:40 pm			29	00	12.8
A. Car	Thursday	5:155 pm			15	30	24.0
B. Bus	11–17–60	4:58 pm			25	00	14.2

HEADWAY AND AVERAGE SPEED OF
LOCAL RUN BUSSES ON THE ARTERIAL STREETS

	Maximum Headway			*Average Speed*					
	am	*Base*	*pm*						
	min.	*min.*	*min.*		*mph*		*mph*		*mph*
E. Jefferson	3	7	3	6am to 9am	12.78	9am to 2pm	14.06	2pm to 6pm	12.78
Gratiot	1.5	7	2	6am to 2pm	14.55	2pm to 6pm	13.71		
Woodward	1.5	3	1.5	6am to 2pm	13.20	2pm to 6pm	12.30		
Grand River	2.5	5.5	2.5	6am to 2pm	13.79	2pm to 6pm	13.14		
Michigan	5	14	5	6am to 9am	13.39	9am to 2pm	13.78	2pm to 6pm	13.39
Fort	2.5	14	2.5	6am to 9am	13.94	9am to 2pm	15.80	2pm to 6pm	13.94

Above information is dated 12–5–60, and supplied by: J. E. Bostick, Superintendent, Transportation Operations, Department of Street Railways.

BUS AND AUTOMOBILE OPERATING SPEEDS

Average operating speeds of automobiles and busses are relatively high. For example, automobile speeds on Grand River in the afternoon peak hours vary from 22.3 to 24.7 miles per hour over a distance of 14.5 miles. Local motor busses on this same street average from 12.9 to 14.3 miles an hour. On the 9.6 miles of Gratiot Avenue between the center of the city and the city limits, the automobile speed varies from 22.2 to 25 miles an hour in the afternoon peak, with local motor bus speeds of 14 to 16.9 miles an hour. The accompanying tables indicate the operating speeds for private motor vehicles and busses during the afternoon and morning peak hours on the main traffic arteries. These facts were obtained through a survey made by the department of streets and traffic. Information obtained from the Department of Street Railways indicating the maximum bus headway and the average speed during various periods is shown in the next table.

The department of street railways has fifteen express lines, most of which operate only in the morning and afternoon peak hours. These lines utilize the major arteries and operate at an average speed of almost sixteen miles per hour over the entire route including the local pickup and discharge operation.

On one line, rapid mass transit is provided by express busses operating over the John C. Lodge Expressway at an average speed of twenty miles an hour in rush hours that includes a local pickup

operation in residential areas and the corresponding local operation in the Central Business District. The complete route covers 18.19 miles with 7.74 miles of this being on the John C. Lodge Expressway.

An important phase of the transportation plan of the City of Detroit is the off-street parking program of the Municipal Parking Authority. Detroit has located its principal parking facilities so as to take full advantage of its expressway program. Long-time or all-day parkers are intercepted near expressway exits and short-time or shopping- and business-parkers reach their parking destination by direct runs over arterial streets.

In addition to the large number of motorists parking in the central business district's more than 25,000 spaces provided by private enterprise, the six garages of the Municipal Parking Authority are parking approximately two million cars per year. The great majority of these cars never become involved in the central business district's local traffic. This results in a minimum of congestion in the downtown area, convenience for the private automobile operator, and greater speed for mass transit on Detroit's downtown streets.

CONCLUSION

Although Detroit will probably never have a rapid transit system such as that in operation in New York, Boston, Philadelphia, and Chicago, some form of mass transit will always be needed. This city would have difficulty operating without transit service. This was demonstrated during the fifty-nine day strike in 1951 when traffic moved only under emergency rules and regulations and as directed by police traffic officers on extra duty.

Transit's role in moving people is demonstrated daily during the afternoon peak hour when almost half of the people leaving the central business district use public transportation. With all of the streets leaving the District now used to capacity during the peak hours, street space would have to be nearly doubled in order to accommodate the same number of people without mass transit.

Detroit needs its surface-street bus system and will improve equipment, service, and routings commensurate with the demand. As the expressway system develops, express bus operation will be expanded over the new highways as needed.

Detroit's plans for the redevelopment of its central business district, cultural center, medical center, and residential redevelopment projects are well under way. The riverfront civic center, with its world-famous convention building, is nearly complete. Detroit plans to continue the program of rebuilding and redevelopment and will prosper with the rapid progress being made in the construction of its highway system. Transportation problems are being solved by use of private transportation supplemented by a surface bus system.

A Realistic Approach to Problems Of Motor Vehicle and Highway Use

LOUIS R. MORONY

Mr. Morony is Director of the Laws Division of the Automotive Safety Foundation, Washington, D.C., a non-profit organization dedicated to education and research for safe and efficient highway transportation, supported by more than 600 companies and associations. A former Assistant Attorney General and Motor Vehicle Director of the State of Michigan, Mr. Morony was the first Executive Director of the American Association of Motor Vehicle Administrators. He is a member of the American Bar Association and the State Bar of Michigan. He served as Chairman of the Highway Laws Study Committee of the Highway Research Board, National Research Council, National Academy of Sciences. He is also on both the Executive and Administrative Committees of the National Committee on Uniform Traffic Laws and Ordinances.

THE three basic elements of highway transportation—highway, motor vehicle, and driver—though separate and distinct, are so closely interwoven in their relationships that it is impossible to set one completely apart from the others in dealing with highway transportation as a whole.

These relationships are well known. Even so, many persons tend to weight one element above another, and to color a view of highway transportation in the light of one or another of its integral parts, depending on the particular interest or responsibility of the individual viewer.

In the eyes of some, for example, highway transportation is characterized primarily by the more than three million miles of roads that criss-cross the country. To others, the motor vehicle and its service capabilities, of major concern, provide another image of highway transportation. Then, there are those who give most of their attention to the driver and his performance; their views on the subject concentrate on the human factor.

This is natural, and there is nothing wrong with it, for each

area is important and worthy of concern and constructive treatment. What is done for improvement in one area helps in the others. But, if we are going to achieve true balance in future development, highway transportation must be viewed in its total dimension, with each of its component parts receiving due attention. Concentration on one part of the problem, to the detriment of another, leads to imbalance which is bound to have an adverse effect.

We are dealing here with a many-faceted subject, yet it can be simplified for purposes of discussion into two almost completely different—although closely related—aspects of the total motor vehicle transportation problem.

ROADS PROGRAM STEPPED UP

One is concerned with the first of the three basic elements: the planning, programming, design, construction, and financing, of adequate highway facilities. Roads are planned and built to serve people, to meet the needs of changing population patterns, to facilitate development of land areas and resources, to accommodate growth of commerce, industry, and agriculture, and to provide a public system of communication conducive to social and economic progress.

The second aspect of the total problem is concerned with the efficient operation of the highway plant, so that the highest potential of service might be realized. Here the other two elements, the vehicle and the driver, come into most prominence.

The operational aspect, then, concerns the driver, his training and his skill, his qualifications for licensing, his performance in traffic, programs for his improvement, and regulations and controls imposed on his possession and operation of the motor vehicle. It concerns the vehicle, its equipment, its maintenance, and operational characteristics. It involves the rules of the road, the system of traffic control, and enforcement of laws and regulations governing vehicle movement.

Today, we are well on our way in realistic treatment of the first aspect of the highway transportation problem. Under impetus of the expanded federal-aid program, we are spending billions of dollars to modernize our highway plant more in keeping with traffic demand, and to provide physical facilities for adequate ac-

commodation of far heavier traffic volumes anticipated for many years ahead.

The stepped-up roads program was launched under the federal aid highway act of 1956, after thorough and comprehensive measurement of present and future needs. Then, it was authorized to meet those needs on an orderly, long-range basis. Since then, the program has been reviewed periodically and its needs re-evaluated to keep up to date.

Not only have physical needs been under continuing review, but also, under sponsorship of the Highway Research Board of the National Research Council, National Academy of Sciences, every element of law having to do with highway construction and management, has been studied and evaluated. As a result of this work, a series of special reports was published, and the reports made available to the states to guide them in handling many legal problems they have encountered. The Board also has sponsored much research on economic and social aspects of highway transportation.

The roads program which evolved from the 1956 Act is impressive in its bulk and scope, but it is more important to note here that Congress did not act until it had the facts on which to base its decision. The bureau of public roads of the department of commerce, and the highway authorities in the several states, had presented factual data on engineering and fiscal needs gathered in thorough mile-by-mile surveys.[1] All planning for the new program was put on a long-range basis. In the individual states, which are responsible for carrying out the improvement program, all planning, programming and financing are of long-range character. All are based on continuing survey of needs.

The public demand and need for better highways have been urgent, strong and evident. This has been true especially since the close of World War II, when unprecedented increases in the use of the motor vehicle followed the end of wartime restrictions on manufacture and sale for public use of vehicles, parts, and gasoline. While the bulk of the nation's resources was directed into successful conduct of war, our neglected highways fell farther behind in their ability to meet transportation requirements.

1. See Needs of the Highway System, 1955–1984, H. R. Doc. No. 120, 84th Cong., 1st Sess., a Report of the Secretary of Commerce to the 84th Cong. Also, see a Ten-Year National Highway Program, the President's Advisory Committee on a National Highway Program (Jan. 1955).

The shock of trying to use the millions of new motor vehicles on roads that had outworn their usefulness brought about a great clamor for highway improvement which, ever since, has tended to play down the importance of the second aspect of the highway transportation problem. This is a demonstration of potential danger of imbalance in highway transportation development.

The public always has been aware of the highway problem, from the days when the cry was to "get us out of the mud" to today, when far better highways and improved performance of the motor vehicle have opened up new horizons of opportunity for faster and more comfortable personal transportation. A highway is a physical thing, which the motorist can see, feel, enjoy or decry, depending on the type of service he feels he is getting from the facility.

USE PROBLEM DEMANDS ATTENTION

The citizen is not so aware of the many problems attendant upon his state government's efforts to regulate and control motor vehicle ownership and use for the protection of property and to safeguard and facilitate use of the vehicle and the highway. Thus, the second aspect of the problem, that which is concerned with the use of the motor vehicle and the highway, has received far *less* attention over the years than the first.

With lack of knowledge, and, generally, a lack of understanding as to the importance and necessity of such governmental activity in their behalf, there are those who seldom think much about it one way or another. They meet the requirements for vehicle registration, take their driver's examinations and licensing as a matter of course, accept traffic controls as commonplace, and, unless they run afoul of the law or become the object of some official restriction action not to their liking, they never raise their voices to be heard on the subject.

There is growing recognition, however, that if we are going to protect the investment in new and improved roads, and assure their bringing a full measure of return in adequate and efficient service, the same careful and continuing attention afforded the highway development program should be directed to the problems of motor vehicle and highway *use*.

Certainly, the operation of such a highway plant as the one in prospect under the current program cannot be entrusted to luck,

nor to hit-and-miss methods of management. It is the use to which the motor vehicle and the highway are put that to the greatest extent controls the efficiency of the highway transportation system. To build highways without providing for safety and efficiency of their *use* would be bad business and sheer folly.

The increasing interest, along with a new sense of urgency, in the use aspects of our highway transportation problem, is becoming more and more evident in the states, especially among legislators, and among those public officials responsible for administration and enforcement of laws, rules and regulations bearing on ownership and use of the motor vehicle.

While there is no overwhelming groundswell of public opinion in that direction as yet, many leading and knowledgeable citizens with interest and background of experience in highway transportation matters are expressing their concern and urging action.

CONGRESS SHOWS CONCERN

The Federal Congress has been showing concern over our rate of progress in dealing with operational problems in the highway transportation field, both in the area of law and in the area of official administration of motor vehicle matters relating particularly to safety. In the last several sessions of Congress a number of proposals for federal action have been advanced and given serious consideration. Congressional committee hearings have been held on this general subject, and findings and recommendations made known to the Congress in special reports.[2]

The department of commerce conducted a study through its bureau of public roads to determine what action the federal government could take to promote the public welfare by increasing highway safety in the United States. A report, "The Federal Role in Highway Safety," was submitted to Congress in 1959.[3]

The report recognized the preeminence of the several states in

2. See, for example, Hearings on H. R. J. Res. 221, 85th Cong., 2d Sess. (1958), before a Subcommittee of the House Committee on Interstate and Foreign Commerce; Highway Traffic Safety, Report 2971 of the Special Subcommittee on Traffic Safety, Report 2971 of the Special Subcommittee on Traffic Safety of the House Committee on Interstate and Foreign Commerce, pursuant to H. R. Res. 357, 84th Cong., 2nd Sess. (1956).

3. The Federal Role in Highway Safety, a report of the Secty. of Comm. to the Congress, on a study made pursuant to Section 117, Federal-Aid Highway Act of 1956; House Doc. No. 93, 86th Cong., 1st Sess. (1959).

this field, stating: "The direct projection of federal authority into highway safety functions that have been the responsibility of State and local governments is concluded to be impractical, and would only weaken State and local authority."

It did make two specific proposals for Federal consideration:

1. National registry or clearance center on records of driver licenses that have been suspended or revoked by a state for cause, with provision that any state could make use of this information in consideration of an application for licensing, for example, on the part of a person moving into one state from another; and,

2. Establishment of an interdepartmental highway safety board, or a national focal point for leadership, guidance and coordination in the many phases of the official highway safety effort throughout the country.

The first of the two proposals was implemented in the 86th Congress, with the Secretary of Commerce directed to establish and maintain such a registry.[4] The second was brought into being by Executive Order of the President.[5]

As additional earlier evidence of Congressional interest and concern, the preceding Congress had passed the so-called Beamer resolution, quite familiar to state officials, giving the states authority to enter into interstate compacts to enhance the safety and convenience of motor vehicle travel across state lines.[6]

These and other Congressional stirrings have created a measure of anxiety among state legislators and officials that the federal government is moving into territory traditionally belonging to the states. Despite the fact that Congress has recognized sovereignty of the states in this field, those qualified to observe the temper of Congress have felt it is only a matter of time until the federal government moves more strongly toward national control of highway safety problems common to every state, if the states fail to act aggressively and positively toward needed improvements. The only way the states are going to lessen that interest in Congress is for the states to do more for themselves along that line.

It would appear the time is ripe, and certainly the need is ap-

4. P. L. 660, 86th Cong., 2nd Sess. (1960).

5. Executive Order No. 10898, Dec. 2, 1960.

6. P. L. 684, 85th Cong., 2nd Sess. (1958), grants ". . . the consent of Congress to the several states to negotiate and enter into compacts for the purpose of promoting highway traffic safety."

parent in every state, to adapt the techniques of long-range factual study to solution of the many legislative and administrative problems encountered by every state government in an effort to regulate and control motor vehicle and highway use in the best public interest.

TIME FOR FACTUAL APPRAISAL

Whatever is done to solve these problems should be based on the solid and sure foundation of full and complete knowledge of the facts that apply. Certainly the state legislature, having the primary legal responsibility, should be fully informed before it is asked to act on such matters. Legislators want to act with the assurance of full understanding of the problems with which they deal. Yet too often they have been forced to pass on the merits of legislative proposals without really knowing what effect they would have on the administrative agency, or their impact on the people of the state.

Administrative officials, too, wishing to base their activities on evaluation of the facts, are hampered by lack of definitive factual information.

Unlike the highway field in which factual data are collected and analyzed constantly to guide in planning, states generally have not developed sufficient data and other information on motor vehicle use to properly inform and guide legislative and administrative action.

The lack of factual information has been recognized by the highway research board. In May of 1960, the board issued a report[7] recommending expenditure of $34 million over the next four or five years for research in areas of special urgency, including importantly the field of motor vehicle administration. Following is a paragraph from the report, which is worthy of considerable thought:

"The practices in the broad field of motor vehicle administration, including such features as driver licensing, motor vehicle registration, titling, enforcement, and associated functions, have not been developed as a result of thorough study of the desirable standards and practices in each aspect of

7. Highway Research Board, Special Report 55, Highway Research in the United States, Needs, Expenditures and Applications (1959), National Academy of Sciences, National Research Council, publication 736.

the area. Rather, they have grown piecemeal as need for added functions in the area became apparent. A thorough appraisal of the problem in all its aspects and the development of necessary standards would permit the placing of motor vehicle administration on a sound realistic basis, with consequent improvement in control of vehicles and drivers in the interest of efficiency of operation and safety on the highway."

The highway research board has been organizing and preparing for a study in depth in the field of motor vehicle registration and titling, a project that is expected to provide some of the answers to problems in that area.

FUNCTIONS IN NEED OF STUDY

Other functions of state government urgently in need of factual study and evaluation in determination of present and future requirements include: Accident reporting and use of accident records, driver education and training, driver licensing, enforcement by highway patrol or state police, financial responsibility, highway operations (activities of the road-building agency to safeguard and facilitate traffic movement after the highway is constructed and put in service), and motor vehicle inspection.

Another area of major importance is the performance of traffic courts in the state's judicial system. Through the leadership of the American Bar Association and the bar associations of the several states, traffic court procedures have been undergoing study in recent years with a view toward stepping up the administration of justice in that field. As part of the traffic court improvement program, seminars for judges and prosecutors have been conducted from one end of the country to the other. This is an example of what can be done with sustained effort and activity in other functional areas of governmental responsibility.

The test of many of these functions is administrative, and hence not susceptible to the same kind of engineering fact-finding as road construction needs. Nevertheless, in the charting of basic law, and determination of authority, manpower, equipment and training needs, much can be done to put these operations on a sound basis, and eliminate the confusion and waste that comes from the traditional piecemeal expediency in motor vehicle matters.

Control and regulation of motor vehicle use will grow more

important and challenging with each passing year. The burden on administrative and enforcement agencies with responsibility in the functional areas involved will expand and get heavier and more complex in pace with ever-increasing traffic volumes, travel mileage and accident exposure.

Failure to plan ahead in the face of much greater traffic demand which new and better facilities are expected to generate not only would be shortsighted, but would, in fact, endanger hard-won gains in accident prevention and in overall efficiency of highway use.

The factual study approach has the endorsement and support of prominent national organizations whose memberships have adopted resolutions to that effect. They are the American Association of Motor Vehicle Administrators,[8] the Institute of Traffic Engineers,[9] and the International Association of Chiefs of Police.[10] The Western Interstate Committee on Highway Policy Problems,[11] a regional body of the Council of State Governments, voted a resolution endorsing the principle of this approach and urging its member states to undertake factual studies. The President's Committee for Traffic Safety also is encouraging and supporting this approach.

LEGISLATURE PRIMARILY RESPONSIBLE

Since the hard task of obtaining results for safe and efficient highway transportation must begin at the place of first responsibility, factual study to determine present and future needs in the area of motor vehicle and highway use should be directed primarily toward the state legislature.

Every state function has its base in law, so it is to the law that one must look first to assure that legal authority, under which the function is carried out, not only is sound and adequate for today, but also is flexible enough to keep pace with changing conditions and requirements in the years ahead.

The several state legislatures have created administrative departments of state government, have granted authority and assigned responsibility for their respective functions, and have perpetuated operation of each function through appropriations of funds.

The legislator's responsibility, however, logically cannot end

8. Resolution adopted Sept. 19, 1958, 26th Annual Meeting, San Francisco.
9. Resolution adopted Nov. 1958, 28th Annual Meeting, Miami Beach, Fla.
10. Resolution adopted by Executive Committee, Oct. 26, 1958, Miami Beach, Fla.
11. Resolution adopted July 25, 1958, Western Region meeting, Seattle, Wash.

with creation of agencies, and provisions for implementation of their functions. Certainly, he has the further responsibility to keep watch over the law in action; the effectiveness of administration; whether the law and what is being done under the law are satisfying the intent and purposes of enactment; whether the people are being served properly under the law. It is important, therefore, that the legislator be as fully informed as possible on all matters of government for which he is responsible through the passage of law.

STUDY PLAN DEVELOPED

A plan of organization and procedure to implement, in any state, the factual study approach to problems of functions bearing on ownership and use of the motor vehicle has been developed and refined over the last several years, and has gained considerable attention and interest among the states. The plan had its beginnings in a special study conducted several years ago by a legislative commission in Indiana to clarify purposes, objectives and functions of motor vehicle law.[12] Expansion of the scope and objectives of that earlier study into the present plan of approach was a logical step. Minnesota adopted this approach in modified form without legislative leadership, and still maintains its organizational structure.[13]

California adopted the recommended plan in its entirety in 1959. It has been carrying out the study program under auspices of the Assembly Interim Committee on Transportation and Commerce, pursuant to House Resolution 381, adopted that year by the Assembly.[14] Other states have shown interest in applying the factual study techniques to solution of their own problems.

12. The Relationship Between Good Traffic Laws and Safe Motoring, a report by the Indiana Legislative Study Commission on Traffic Safety (1955).

13. Preparing now to Meet Future Legislative Needs of Motor Vehicle Ownership and Use, Work Manual, Stage 1, Minn. Motor Vehicle and Traffic Laws Study Comm. (1958); Also see, Minn. Program of Action, Governor's Motor Vehicle and Traffic Laws Study Comm., Aug. 22, 1958.

14. Resolution No. 381 (1959) Calif. Assembly, Relative to Studies of the Administration of Motor Affairs. Also see, study guides issued by Calif. Assembly Interim Comm. on Transportation and Commerce: A Factual Study of State Functions Bearing on Ownership and Use of Motor Vehicles, Outline of Organization and Procedure: and Stage Two of Factual Study of Needs, Analysis and Evaluation of Facts Gathered in Stage One. Also Interim Com. reports to the Calif. Assembly; see, Motor Vehicle-Use-Ownership-Operation, A Progress Report on Development of Factual Studies in Calif. Directed by H. R. 381, March, 1960; and Keeping Pace with Needs of Motor Vehicle Ownership and Use, A Report on the First Stage of a Factual Study Program, Initiated Under Direction of H. R. 381, January, 1961.

Everyone so far involved in the California study has realized that a study of this type is essentially of long-range character; that it is intended to provide a master blueprint for legislative action to keep pace with developments, as well as guidance to the department administrators responsible for the various functions under study.

It should be recognized that a study of such magnitude and complexity must be undertaken step by step, in order that the process can be both orderly and thorough. Further, nothing short of thoroughness in each of those steps should be accepted, in the interest of carrying out the study project to fullest possible potential of benefit.

The recommended plan for study has been divided into three steps: (1) Fact-gathering, (2) Analysis and evaluation of the assembled facts, and (3) Development of an action program to meet present needs and those anticipated in the future.

PURPOSE AND OBJECTIVES OF STUDY

The purpose of such study:

To enable the legislature, in keeping pace with developments, to come into possession of all the facts relating to motor vehicle ownership and use, thereby permitting it to exercise its full responsibility in providing funds and authority to the responsible officials, in order that use of the highways and streets now built, or being built, will adequately serve the needs of the people efficiently and safely, both for the present and in the future.

From the outset, two ultimate objectives should be borne in mind:

1. To make it possible for the several departments of state government to determine the extent of their future responsibilities in each functional area. This would be a factual and *quantitative* measurement of what each function must be geared to accomplish in the years ahead under impact of continued growth of the state.

2. To evaluate each function and its proper role in state government, to the end that a better common understanding and appreciation of its purposes and objectives might be realized by the Legislature, the public, and the officials. This would be a *qualitative* measure of each function, to point up the value of its services, and how it can be made more effective.

Successful conduct of a study of such magnitude and technical complexity depends in large measure on how well the project is planned and organized. Subjects to be studied in any one of the functional areas are of such importance, and the work so demanding of time, manpower and thought, that all planning and organization should be deliberate and careful, thus assuring that whatever is needed to do a thorough and complete job will be provided.

ORGANIZING FOR STUDY

Time spent on putting the study on a solid footing is time very well spent. This type study cannot be undertaken lightly, nor carried out hurriedly, for if fullest possible benefit is to be derived it will require the best effort of qualified people, and more thorough treatment than these subjects have ever had in the past.

It should be emphasized from the beginning that it is not an efficiency study of departments, as that term is commonly understood, rather it is a study of each state function, as a function, no matter where it may be placed in government. It is necessary, therefore, that the study organization and plan provide for full treatment of a function quite apart from any other, even though many interrelationships will be found and must be considered as part of the study of any one function.

Following are some of the essentials of effective organization:

1. Support and co-operation of the Governor.
2. Leadership of a legislative study committee.
3. Adequate financing.
4. Participation of all departments concerned.
5. Citizen's advisory committee.
6. Assistance of technical consultants in each functional area.
7. Co-ordination through a study director.

Thus are brought together the lawmaker, the public official, and the interested citizen, working as a team toward better government. Such an arrangement is conducive to a high level of sympathetic understanding and cooperation in getting the desired results out of the study program.

Legislative leadership in this work is a primary essential, since that is the place of basic responsibility, and since the entire study project is pointed first toward what the Legislature can do to meet present and future needs of each function. With a legislative com-

mittee directing the program, findings, conclusions and recommendations finally evolved should have far greater acceptability in the lawmaking body than otherwise might be the case.

LEGISLATIVE LEADERSHIP ESSENTIAL

It is important that the governor lend his support, for it is under the Executive office that the administrative agencies function. Full participation and co-operation of departments in which are housed functions to be studied is an obvious requirement for it is through them the study must be accomplished, and in those departments are the people best qualified to deal with their respective subjects.

The departments are the backbone of the study structure, for under this plan they have the responsibility for doing the actual study work. They would gather the facts and determine their meaning in relation to performance of the function. It should be agreed from the outset that, with all technical phases of the study in their hands, the departments will draw their own conclusions from findings of the study, and at the proper time in the study process submit their recommendations to the legislative committee.

From time to time, the departments will find it necessary to make use of outside technical counsel, especially in the analysis stage, to get the broadest possible base for evaluation of facts and for sound judgment. The legislature, therefore, should make early provision for funds available to the departments for that purpose, as well as for funds for the committee's use in administering the program.

Certainly, the public should be a partner in such a venture, for in the end it is the citizen for whom the study is undertaken, and it is the citizen who submits to regulations and controls, and pays the tax bill to support the functions of government.

An advisory council of citizen leaders should be chosen, then, including in its membership representatives of organizations with business or humanitarian interest and concern, and other leading citizens qualified by reason of their interest, background and experience, to contribute to the success of the study. To this group the legislative committee would turn for advice and counsel in deliberations throughout the program.

It is good business to place administrative details of the study

in the hands of a study director, named by and responsible to the legislative study committee, acting as an agent of the committee in all matters relating to study procedure, and maintaining close liaison and working relationship with the departments.

The success of the study program so far in California, in which at this writing the entire first stage of fact-gathering has been accomplished, bears out the importance of the foregoing elements for organization. The Automotive Safety Foundation, on whose staff the author serves, has been privileged to assist in the development of the California study and to act as study director under an agreement with the responsible Assembly Interim Committee.

EARLY BENEFITS RECOGNIZED

A number of early benefits have been recognized in California as already justifying the time, and the effort, being put into the study project. Some of these results are tangible, some intangible, but nevertheless real and worthwhile.

For example, to give them only partial mention, the study has brought into closer co-operative working relationship the three administrative agencies immediately involved: The department of highway patrol, the department of motor vehicles, and the department of public works, highways division.

Their administrative heads and staff assigned to direction of the study work have worked out co-operatively, and have reached agreement, on many important details of study procedure. This already has led to better understanding and greater knowledge in each department of the operations and problems of the others. It has been a forward step in inter-agency co-operation.

The departments have had, through the study structure, the sympathetic attention of the legislative body, and the public, as they unfold the story of their functions and their operations in service to the people of the state. This relationship will stand them in good stead when they come to the time they must make a factual case for their recommendations.

The relationships and better understanding between the lawmaker, the official, and the public, being fostered in the study, cannot help but have lasting beneficial effect on the future of government in California.

Further, the administrative departments have found in the first stage of the study process much factual information which they have declared has had, even at this point in the study process, considerable influence on the future of the function, with changes in administrative policy and procedure already having been instituted as a result of this work.

This information, they have declared, should prove of value in training of departmental personnel, and provide a reservoir of information with which to bolster their public information program.

This is the first time the present administrators have had such an opportunity to review thoroughly what is being done under each function, how it is being done, and why. Heretofore, the daily task of trying to keep up with the sheer bulk of workload had militated against such exhaustive review and evaluation.

While the workload is still there, to even greater degree than ever before, there is recognition that the extra effort demanded by the study now is essential if their respective functions are to be equipped for adequate future service.

These, along with others which have not been discussed here, are partial benefits that any state can reap early in the study process. They are only a beginning of what can be realized if such study is carried out to its ultimate objectives.

GATHERING THE FACTS

Obviously, before any state can determine its needs, present or future, a comprehensive study of current activities must be made. Therefore, the first stage of the study process calls for breaking down each function into its essential elements, and gathering together in usable form all available and pertinent information in each of those areas of functional authority, responsibility and operations. Every source of information bearing on the function should be tapped.

In addition to data and other information from departmental files, and from findings of previous departmental studies, much valuable information can be obtained from such outside sources as the National Safety Council's annual inventory of traffic safety activities, the American Automobile Association's pedestrian protection contest, the national high school driver education award program, now administered by the Insurance Institute for Highway

Safety, as well as other special inventories in which states have participated. Findings and conclusions of outside research and surveys in the same subject areas under study in the state might well be sought out in this stage of the work.

Further, it is helpful to trace the historic development of each function and its activities, for it is against the background of past practices and experience that present deficiencies can be properly documented and understood, and future needs projected.

In developing historical data, the starting point is the law that created the department or agency, gave authority, and sssigned responsibility for the function. Through such review, it is possible to relate authority, budget, and other such factors to effectiveness of administration under conditions existing at any given period of time. These relationships become important in later evaluation of accumulated facts.

Each function under study must be viewed in light of every factor influencing its development over the years, and its current status. Factual information, then, is needed on such internal influences, or operational factors, as legal authority, administrative policies and practices, annual budgets, personnel, equipment and facilities, co-operative relationships with other agencies of government, and public acceptance.

Facts must be gathered on certain outside influences over which the Legislature and the administrative agency have no control, but which are of overwhelming consideration in determining the scope and direction of the function and its operations. Among them are population growth, vehicle registration, increases in motor vehicle travel, traffic accidents, and changes in the economy of the state.

Every factor which has had, or is likely to have, bearing on the function is important in a study of this kind.

ANALYSIS AND EVALUATION

With all essential facts brought together in an orderly manner, the job of putting the information to work can begin. The factual study then takes on substantial meaning and importance. In this stage, the function is taken apart piece by piece, and each of its elements is subjected to the closest critical scrutiny. It is then put back together, so to speak, for a more perfect picture of the function,

its needs, and its potentials of service. Here the internal and external influences should be fully considered in the light of their past impact on the function, and projections developed to anticipate future demands.

Here, too, all interests, both public and private, must be recognized in review of every element of every function. Along with legislators, and officials responsible for administration of law, there are many others affected by and greatly interested in what is being done under the law. These include, but are not exclusive of, business and industry, especially automotive, organizations representing motorists, trucking, agriculture, insurance and finance companies, and banking interests. As a matter of fact, since the whole economy of the state depends in large measure on the welfare of automotive transportation, just about everyone is interested in getting the maximum benefit from the governmental functions relating to ownership and use of the motor vehicle.

Obviously, the backlog of information gathered in the first study stage has value only if it can be interpreted and translated into terms of study objectives. Every provision of statutory law applying, and everything done to carry out its administration must be held up to view to obtain a true measure of suitability, adequacy and effectiveness as a function is performed today, and what will be required to equip the function for adequate service in the years ahead.

It is in this stage of the work that accepted standards in each functional field under study would be applied to help measure performance of the function. In some cases nationally recognized standards might have to be modified to fit conditions peculiar to the state. Where such standards and criteria are lacking, those responsible for administration of a function would want to develop them for their own use in determining a desirable level of performance.

It is important that the intent of the law, and the purposes and objectives of the law and the function through which the law is carried out be given primary consideration throughout the analysis stage, for they spell out what the law was designed to accomplish and what the administrative function is expected to do to properly serve the people. At the outset, agreement should be reached as

to what these purposes and objectives should be to realize optimum benefit from the function.

As to statutory law, the Uniform Vehicle Code for many years has been the nationally accepted guide to legislation in the motor vehicle field. It has been revised periodically to keep it up to date.[15] Here again, it can be used as a standard to make sure the state's law has kept pace with developments and has taken full advantage of the latest experiences in other states.

OBJECTIVE EVALUATION IMPORTANT

Analysis and evaluation of facts should be approached objectively, with completely open mind, if fullest value is to be gained from the study. Suggestions and constructive criticism of knowledgeable persons, from inside and outside the department, should be welcomed on every matter being considered.

The responsible administrator would want to bring into the work at this stage as much imaginative thinking and fresh viewpoints as can be enlisted. Opening up matters of policy and major operational problems to such broad review should bring about better understanding of the function and its needs, and result eventually in stronger support from the Legislature and the public than otherwise might be realized.

The analysis stage is the logical time to bring into the study the advice and counsel of professional consultants, especially in technical matters, so that their skills can be put to full use in helping the administrator arrive at sound conclusions. Judgment on all matters should have the broadest possible base, and the highest possible degree of validity.

While the emphasis would be on foresight and preparation for the years ahead, during the course of the study certain urgent needs will become apparent and demand immediate attention, either through legislative or administrative action. Such needs, of necessity, would be acted upon promptly, as has been customary in every state. There is no thought here of delaying action on matters that simply cannot wait out the full course of the study program.

Throughout all stages of the study, it should be borne in mind

15. Uniform Vehicle Code, Revised 1956, National Committee on Uniform Traffic Laws and Ordinances, Washington, D.C.

that laws are in the interest of the general public, and that administration of those laws is to serve the people. Therefore, the law itself, and everything done under the law, must be studied with emphasis on the side of positive service, rather than on the negative, or punitive side. Such study is directed toward safeguarding and facilitating to highest possible degree the ownership and use of the motor vehicle, and traffic operations on the highways of the state.

POSITIVE SERVICE SHOULD BE STRESSED

In other words, stress should be put on what laws and administration do *for* people, rather than *to* people. Everything possible should be done to bring about citizen-understanding of what is being done, how it is being done, and why it is being done—for the public.

It bears repeating that unless the law is sound and understood; unless the legislation is intelligently enforced or administered; unless the motorist believes the law is designed for his self-preservation; unless he is willing to pay the cost; unless he believes the law does things *for* him, not just *to* him—the citizen cannot be expected to believe in what the law hopes to accomplish.

Law contained in the statutes today needs thorough study and evaluation. Many of our laws were passed by legislators no longer in office. Original purposes and objectives have been lost sight of because of amendments, repealed section, etc. The philosophy of administration has undergone change, often because at the outset there was no clear declaration of legislative policy to give sound direction.

Every motor vehicle law has a positive objective. All are geared to the self-preservation of people, and should always be viewed in that light.

For example: The driver-license examiner wishes to be sure the applicant knows how to perform safely as a driver. His business, however, is to *help* the citizen obtain a license. He should do everything possible to make sure the person has the necessary qualifications.

Many persons wear glasses. It is quite likely that on their driver-licenses is stamped the word "restricted." This is not so much a restriction as it is a positive requirement for self-preservation,

comparable to the use of special devices built into cars to make it possible for people with other physical handicaps to enjoy the driving privilege.

As another of many examples: Arresting people is not the principal function of the highway patrol or the state police. Rather, their business is to see that the driver's movements in traffic can be accomplished expeditiously without danger to himself or others. The officer has the power to arrest any motorist who refuses or fails to conform to rules and regulations, and that is as it should be in the public interest.

While the public interest demands certain punitive measures directed against those who will not, or do not for some reason, abide by the rules of good conduct on the highway, the fact remains that government's primary purpose is to help drivers enjoy the driving privilege and our modern facilities, instead of restricting and denying that privilege.

NOT MORE LAW, BUT BETTER LAW

It should be mentioned, too, that the purpose of factual study is not to add more law to statute books already jammed with legal provisions. Rather, it is to assure that the law which is needed is there, that it can do the job the state needs, and that it offers maximum protection and service to the people of the state.

Basically, there is nothing wrong with the addition of law, if we are satisfied that by obtaining more law we are accomplishing our objectives. Actually, though, after thorough review and evaluation of the laws now in effect in a state, less and better law, rather than more law, might be the result.

There is another very valid reason for factual study of functions bearing on ownership and use of the motor vehicle, and for making the public a partner in the project. The taxpayer in every state is carrying an extremely heavy load in government, for schools, welfare, defense, and other needs, including, very importantly, provision of adequate roads and other highway transportation services and facilities.

He does not always know what he is getting for his tax dollar. Nowhere in government is there more opportunity and need for showing results and giving an accounting for these taxes than in the

field of motor vehicle ownership and use. Certainly, the citizen has a right to know not only how his dollars are being spent, but whether he is getting maximum value out of every dollar he puts into taxes.

The results of a study project such as has been outlined here can be of tremendous importance to the people of any state, providing that the self-analysis can be carried out in completely objective and factual manner. This may mean that some of the laws and some of the procedures over the year may be found wanting. If so, it could be an entirely healthy development.

On the other hand, it may be found that everything possible to do is being done, and that by carrying out the same procedures further in the years ahead, the function under study can serve adequately and effectively in meeting future requirements. This, too, would be beneficial, for it would provide proof of well-being, that might not have been capable of proof before.

It is only through such periods of study and self-examination that the performance of government is adjusted to meet changing times and changing needs of the state's citizens.

It will be necessary, however, as has been found in the highway development program, to review periodically the findings and conclusions of the factual study of needs in the field of motor vehicle ownership and use to assure that the improvement program is kept current with developments over the years.

Improvements brought about through such factual study will result in greater safety, not attainable in any other way, and will have important impact on the efficiency of the highway transportation system.

Proposed English Channel Tunnel: Its Estimated Traffic and Revenue

WALTER A. BARRY, JR.

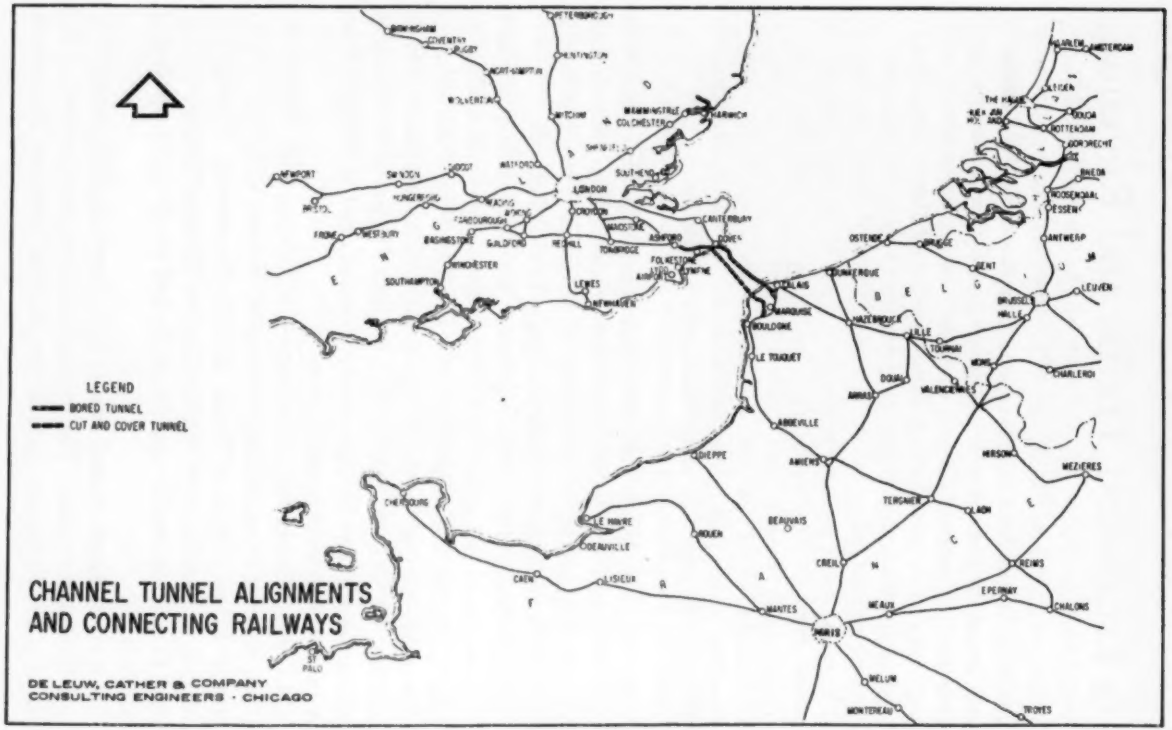
Mr. Barry is Assistant Chief Transportation Engineer of De Leuw, Cather and Company. As a member of this consulting engineering firm, he was a special consultant to Groupement d'Études du Tunnel sous la Manche (Paris) on traffic and economic studies for the proposed channel tunnel. Other recent assignments include the position of engineer-economist on a feasibility study for a 300-mile railroad link to connect the railroad systems of Turkey and Iran. This project is now under construction. Mr. Barry also directed traffic and revenue studies for six Delaware River Bridges, the second Elizabeth River Tunnel and the Hampton Roads Tunnel in Virginia, as well as for turnpikes in Massachusetts and Oklahoma. As project manager for a variety of traffic, transit and parking reports, he has represented De Leuw, Cather and Company in many of the larger cities in the United States and Canada.

FOR 150 years many able men, including Napoleon Bonaparte and Winston Churchill, have tried to overcome the political, economic, engineering and military obstacles to construction of a tunnel under the channel between England and France.

Recent efforts of important interests, not only in England and on the continent but also in the United States, now seem close to success. Comprehensive investigations of all aspects of this spectacular proposal have given encouraging indications that the tunnel is physically, as well as financially, feasible. Legal and financial negotiations are now being actively pursued, and it is hoped that construction can start within a year.

De Leuw, Cather and Company of Chicago, with Walter P. Hedden serving as consulting economist, Societe d'Etudes Techniques et Economiques of Paris, and the Economist Intelligence Unit, Ltd. of London were retained by the Channel Tunnel Group in 1958 to estimate traffic and revenues and to advise on operating techniques.

Several alternate tunnel routes have been studied intensively during the last four years. The general location most favored at the moment is the narrowest part of the channel between Folkestone


LEGEND
BORED TUNNEL
CUT AND COVER TUNNEL
CHANNEL TUNNEL ALIGNMENTS
AND CONNECTING RAILWAYS
DE LEUW, CATHER & COMPANY
CONSULTING ENGINEERS · CHICAGO
LONDON
CANTERBURY
FOLKESTONE
CALAIS
DUNKERQUE
BOULOGNE
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BRUGGE
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BRUSSELS
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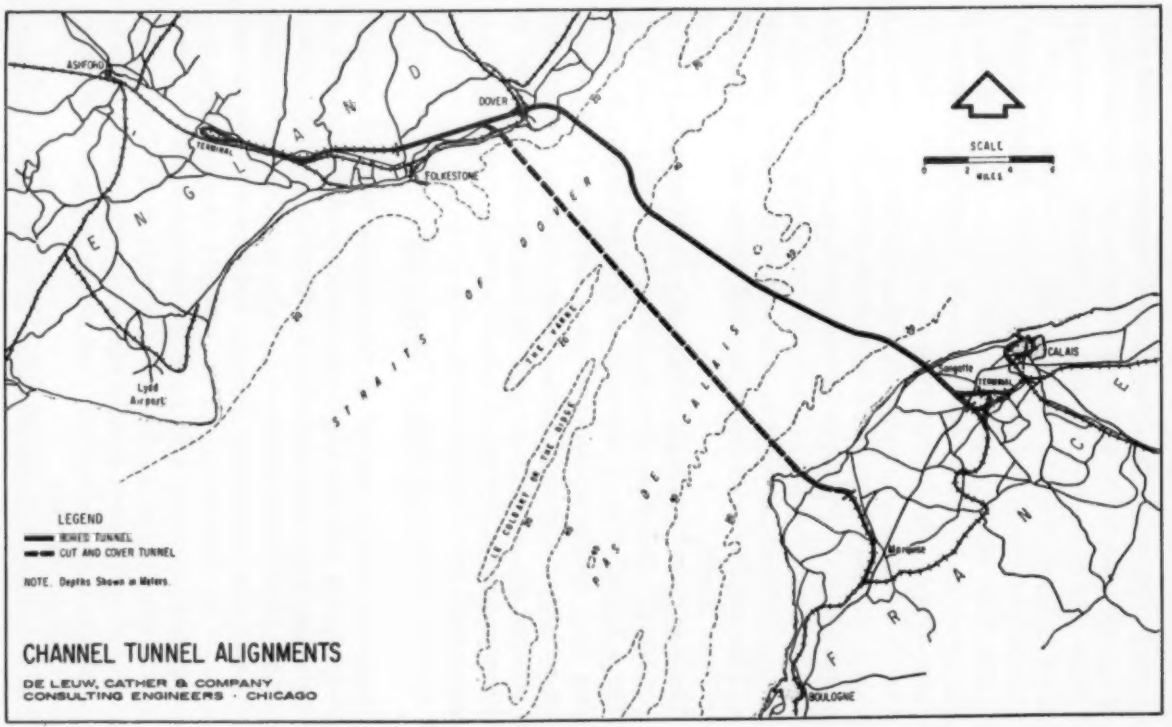
Figure 1.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CHANNEL TUNNEL ALIGNMENTS
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Figure 2.

on the English coast and a point some four miles south of Calais on the French coast. While the channel is only twenty-two miles wide at this location, the distance between portals would be about thirty-five miles. The additional length is occasioned by the long slopes required to climb from approximately 250 feet below sea level to the top of the cliffs on both sides of the channel. Figures 1 and 2 show two of the alternative lines for the tunnel.

Economic studies determined the probable traffic and revenues for three distinctively different types of facilities: (1) a tunnel for railroad trains only; (2) one for highway vehicles only; and (3) a combination tunnel that would serve both classes of traffic. For many reasons, including the problem of ventilating a tunnel carrying road vehicles, it is likely that an electric railway tunnel will be built first. A second tunnel for road vehicles may be built at a later date. This article discusses only the findings in connection with the railway tunnel.

The tunnel will probably consist of twin tubes with a single railway track in each tube. One proposal is to build the tunnel from a "Texas Tower" type of construction platform. A trench would be dug from the tower, and sections of precast concrete tunnel would be lowered into the trench, fastened together, covered over and pumped dry. Another method, reported practical, would be to bore twin tunnels through the chalk, found by various explorations to extend from shore to shore.

OPERATIONAL PROCEDURES

Passengers will be carried in conventional railroad coaches. Passenger trains will travel between London and Paris as well as between other large cities in the United Kingdom and cities on the Continent. Many trains, however, will simply shuttle between terminals near the two portals. Vehicles will be carried on railway flat cars for the portal-to-portal trip with the accompanying passengers remaining in their vehicles. This method is successfully used in the ten-mile St. Gotthard and twelve-and-a-half-mile Simplon Tunnels in Switzerland. Freight will be transported in conventional railway cars, in containers, and also in trucks carried piggyback on railway flat cars.

Efficient marshalling yards with all facilities needed to accom-

modate passengers, highway vehicles and freight will be constructed near the portals at either end of the tunnel. The peak hour capacity will be twelve trains an hour in each direction, with total potential operation over a sixteen-hour day of 125 trains in each direction.

Passenger trains will have six-hundred- to eight-hundred-person capacity. Vehicle trains will be able to carry 300 automobiles, while freight trains will have 600 net ton capacity. Average tunnel speeds will be approximately sixty-five miles an hour for passenger trains, fifty-five miles an hour for trains carrying passenger vehicles, and forty-five miles an hour for freight trains.

The movement of passengers and vehicles across the channel is highly seasonal; approximately twenty-five percent of both types are handled in the month of August, and approximately seventy percent within the four months of June, July, August and September. There is further concentration of traffic on week-ends during the summer.

Of the 5,750,000 passengers crossing the channel in 1957,[1] 3,191,000, or 55.5 percent, traveled by sea and 2,559,000 or 44.5 percent by air. At present there are eleven main sea routes for the transport of passengers across the channel. The consultants were instructed to assume that six of these sea routes—those opertaed by the British and French Railways—will be disontinued with the opening of the tunnel. Of the 3,191,000 passengers carried on all sea routes, 1,529,000 were carried on routes to be discontinued. A summary of passengers carried by these facilities in 1957 is shown in Table I.

Trans-channel services include regular inter-city air transport and special air transport between terminals near the coasts, operated in conjunction with bus and rail service. Patronage has increased rapidly since inauguration of these services. Table II shows total air passenger traffic between the United Kingdom and various European countries in 1957.

The overall running time between London and Paris rail terminals will be about four and one-half hours. In contrast, the present "Golden Arrow" train-ferry-train service via Dover-Calais takes eight hours. The night ferry via Dunkerque, which carries through

1. Since the data were collected in 1958, 1957 was the last full year for which complete information was obtained.

railroad sleeper cars, takes about eleven hours. The tunnel fare is proposed to be approximately $4.50 per passenger, approximately equal to the present Dover-Calais Ferry fare.

TABLE I—SEA PASSENGERS BY ROUTE IN 1957
(NOT INCLUDING THOSE IN VEHICLES)

Route	*Carried by Sea in 1957*	*Percent of Total*
To be discontinued		
Dover–Boulogne	35,000	1.1
Dover–Dunkerque	88,000	2.8
Dover–Calais	387,000	12.1
Newhaven–Dieppe	322,000	10.1
Folkestone–Boulogne	320,000	10.0
Folkestone–Calais	377,000	11.8
Total to be discontinued	1,529,000	47.9
To remain		
Dover–Ostend	868,000	27.2
Harwich–Hook	478,000	14.9
Southampton–Le Havre	57,000	1.8
Harwich–Esbjerg	56,000	1.8
Southampton–St. Malo	35,000	1.1
Other Routes	168,000	5.3
Total to remain	1,662,000	52.1
Total carried by sea	3,191,000	100.0

TABLE II—AIR PASSENGERS IN 1957
(NOT INCLUDING THOSE IN VEHICLES)

Between United Kingdom and	*Number of Passengers*	*Percent of Total*
France	838,000	32.8
Germany	337,000	13.2
Switzerland	313,000	12.2
Netherlands	284,000	11.1
Belgium	216,000	8.4
Italy	174,000	6.8
Spain	166,000	6.5
Others	231,000	9.0
Total	2,559,000	100.0

The cost of the London-Paris journey is about $13.00 for a second-class passenger, including the crossing charge. A trip via Dunkerque costs about the same. The proposed London-to-Paris fare via the tunnel is comparable with present fares.

The present elapsed time of a London-Paris scheduled air trip from city center to city center is almost four hours. The fare on a scheduled air trip from London to Paris is $25 for a tourist ticket. The fare on the Beauvais-Lympne "Skyways," a six-hour London-Paris service, is $14, with total cost of the trip, including coach service to and from the airports in London and Paris, being $16.00.

SURVEYS DETERMINE TRAVEL PATTERNS

Origin-destination surveys were conducted in 1958 to determine the characteristics of passenger traffic across the channel. Surveys were made during the summer vacation season, July and August, as well as in the off season, October. The interviews were conducted for three weekdays, a Saturday and a Sunday for each route and in each season.

The main purposes of the survey were to determine the pattern of the travelers taking each route across the channel, and to learn the reasons for their choice of route and mode of transport. Other information, such as nationality, purpose of trip, occupation, and length of trip, were also obtained to help understand the traveler's choice of route.

Interviews were taken on the boat trains and at the seaports of Harwich, Dover, Folkestone, Newhaven and Southampton. Air passengers were interviewed at the airfields of Southend, Lympne and Ferryfield. Effective interviews of approximately 55,000 air and sea passengers were thus obtained. Information used also included that gathered through independent surveys by various government agencies in 1957 and 1958 at the London and Orly (Paris) airfields.

Analysis of the origin and destination information showed that the number of passengers using various alternate routes had a direct relationship to the cost of using each alternate route. The best correlation in the data was found when the average passenger's time was valued at approximately $0.24 an hour, and trip cost was assumed to include actual fares paid. By assigning monetary values to time, fares, and intangible benefits, it was possible to derive allocation curves that could be used to assign passengers to the Channel Tunnel. The number of passengers estimated to be divertible to the tunnel increased, therefore, with increases in the actual and

attributed monetary saving of the tunnel over the alternate route.

Approximately sixty-eight percent of the passenger traffic estimated to be diverted to the Channel Tunnel will come from passengers formerly conveyed on discontinued sea routes, as shown in Table III. The remainder will be diverted from the continuing sea routes and from some of the existing short-haul air routes.

TABLE III—EXISTING AND ESTIMATED DIVERTED PASSENGER TRAFFIC

Passengers	*1957* *Actual*	*1965* *Estimated Without Tunnel*	*1965* *Estimated Diverted to Tunnel*
Sea—Discontinued routes	1,529,000	2,170,000	2,170,000
Retained routes	1,662,000	2,358,000	428,000
Sub-total	3,191,000	4,528,000	2,598,000
Air—Regular route: London–Paris London–Belgium London–Netherlands	1,032,000	2,837,000	532,000
Other routes	1,527,000	4,043,000	50,000
Sub-total	2,559,000	6,880,000	582,000
Total	5,750,000	11,408,000	3,180,000

Of the 2,559,000 total air passengers crossing the channel in 1957, 1,032,000, or approximately forty percent, were carried on certain regular routes between London and Paris, London and the Netherlands, and London and Belgium, on which the distance between airports is 250 miles or less. Approximately 116,000 passengers crossed the channel between the United Kindgom and France on short routes other than London-Paris. The 1,411,000 air passengers traveling in 1957 on routes where the distance between airports is greater than 250 miles were not considered as potential traffic for the tunnel.

Projected train travel times through the tunnel from city center to city center compare favorably with air travel times on these routes. Only seventy-five percent of regular route passenger air travel of 250 miles or less was considered as potential to the tunnel. Consultants have estimated that twenty-five percent of these potential passengers will be diverted to the tunnel.

A summary of 1957 actual, estimated 1975 without tunnel, and estimated 1965 diverted traffic is shown in Table III.

The number of passengers is estimated to increase from 3,180,000 in 1965 to 5,092,000 in 1985. The estimated revenue, based on an average fare of approximately $4.50, will increase from $14,384,000 in 1965 to more than $23,000,000 in 1985.

VEHICLE TRAFFIC ACROSS CHANNEL

The number of vehicles crossing the channel increased from 113,600 in 1949 to 285,900 in 1957. Of the latter, approximately 81.6 percent went by sea and 18.4 percent by air. Table IV summarizes the vehicular traffic for 1957.

TABLE IV—1957 VEHICULAR TRAFFIC

Item	*Number*		
	By Sea	*By Air*	*Total*
Vehicles	233,300	52,600	285,900
Occupants of Vehicles	696,000	140,000	836,000

All air ferry and sea ferry services are frequently booked to capacity during the peak periods, especially during the August holidays, although the unused capacity in off-peak periods is very large.

There are six main sea routes transporting accompanied vehicles. The consultants were instructed to assume that four of these —operated by the British Railways and the French Railways— will be discontinued with the opening of the tunnel. Vehicles carried on all routes in 1957 numbered 233,300, of which 165,800 were carried on routes to be discontinued. Approximately ninety percent were passenger vehicles. The average occupancy was just over three persons. A pertinent summary of the traffic in 1957 is shown in Table V.

Air transport ferrying of vehicles, a postwar development, is reaching substantial proportions. In 1949, only 2,700 vehicles were ferried by air. In 1957 this figure had increased to 52,600. Of these, 44,600 were passenger vehicles. With the development of larger and more economical aircraft, the popularity of this method will probably continue to grow. Most of the routes are short-hop routes ferrying the vehicles between airports near the channel.

The charge for the vehicle and three passengers for the cheapest air-ferry, Ferryfield-Le Touquet, averages close to $50, compared with some $30 for the nearby Dover-Boulogne sea ferry. For the tunnel passage, the average automobile fare including three occupants will be approximately $21.50, which compares favorably with average air and sea ferry fares mentioned above. The total travel time between London and Paris via tunnel will be approximately eight hours—about the same as for motorists now taking the air ferry, and between two and one-half and five hours faster than motorists' time via sea ferry.

TABLE V—VEHICLES BY SEA ROUTE IN 1957

Route	*Number of Vehicles*	*Percent of Total*
To be discontinued		
Dover–Boulogne	96,671	41.5
Dover–Dunkerque	35,507	15.2
Dover–Calais	23,968	10.3
Newhaven–Dieppe	9,643	4.1
Total using routes to be discontinued	165,789	71.1
To remain		
Dover–Ostend	41,777	17.9
Harwich–Hook	12,439	5.3
Other routes	13,249	5.7
Total using routes to remain	67,465	28.9
Total carried by sea	233,254	100.0

Motorists now drive their vehicles to air and sea terminals near the channel, to be transported across the channel by air or sea ferries. When the tunnel is completed, the operation will be similar except that the motorist will be carried through the tunnel on railway flat cars, remaining in his own vehicle.

It is estimated that the total railway tunnel time for motorists will be 83 minutes—22 minutes waiting, 12 minutes loading, 38 minutes traveling, 4½ minutes unloading, and 6½ minutes in customs inspection.

Origin-destination surveys of accompanied vehicle traffic across the channel were conducted in 1958 to determine routes taken by motorists and reasons for their choice. As in the passenger surveys, motorists were interviewed on five days in the vacation season and five days in the off-season. Other information—vehicle type, num-

ber of accompanying passengers, nationality, purpose and length of trip, occupation, and mode of transport of cars to the seaport or airport—was also obtained.

Interviews of accompanied vehicle drivers took place at the seaports of Harwich, Dover, Newhaven and Southampton; and Southend, Ferryfield and Southampton airports. Interviews were generally conducted on the parking lots leading to customs for outgoing vehicles, and at the exits of the customs sheds for incoming vehicles. Effective interviews of more than 11,000 vehicle-drivers were thus obtained.

Analysis of origin and destination information showed that the relative number of motorists using various alternate routes had a direct relationship to the cost by way of the alternate routes. The best correlation in the data was found when the average motorist's time was valued at approximately two cents a minute. The distance driven was priced at four cents a mile, and trip cost included the actual fare paid for the channel crossing.

Since time, distance, and fares were all converted to monetary values, it was possible to derive allocation curves that could be used to assign motorists to the Channel Tunnel. The portion of these motorists estimated to be divertible to the tunnel increased, therefore, as the estimated monetary savings for trips via the tunnel increased.

About two-thirds of the vehicles estimated to be divertible to the Channel Tunnel will come from vehicles formerly carried by ships to be discontinued. The remainder will be cars formerly carried by airplanes and retained sea routes.

Traffic generation develops during the first few years of operation of a fixed crossing that replaces ship and ferry service. Such generated traffic is in addition to the traffic which would have crossed at that location if limited to the previous facilities. The additional traffic appears not only because of improved service provided by the new facility, but because of lower costs and changes in travel (vacation and business) habits.

The percentage of generated traffic varies with the amount of fare charged. Based on a fare approximately seventy-six percent of that prevailing on the least expensive existing routes, it was calculated that the generated traffic would be approximately sixty percent of the diverted traffic.

It is estimated that vehicle traffic will increase approximately in proportion to the increase in vehicle registrations; the increase between 1957 and 1965 has therefore been estimated at sixty-three percent. The number of vehicles is estimated to increase from 676,000 in 1965 to 1,196,000 in 1985. Based on an average fare of slightly less than $22, the 1965 and 1985 annual vehicle revenues were estimated at approximately $14,736,000 and $26,256,000.

FREIGHT TRANSPORTATION

Approximately five percent of the freight of the type potential to the tunnel is carried across the channel as air freight, while the remaining 95 percent goes by sea on loose-cargo routes, rail ferries, and roll-on roll-off truck ferries. Freight is delivered to dockside in railway cars and trucks. Since the continental loading clearance gauges are larger than the English, it is not possible for continental railway cars to travel on the British Railways.

There are now three basic types of railway cars in operation—English, continental and ferry gauge. Specially designed vehicles known as ferry gauge cars[2] are carried across the channel on the rail ferries and can operate on both the English and continental railways.

The tunnel will be designed to take all three types of railway cars in addition to flat cars carrying highway vehicles and containers. Freight carried on either the English or continental cars will be transferred at one of the two marshalling yards.

The complexity of the many types of goods being shipped across the channel dictated the need for obtaining a variety of information to determine the kind and amount of freight potential to diversion to the tunnel. Relevant information was obtained from various European ports, shipping lines, manufacturers, consumers, and railway companies. It was possible to combine these data into a reasonably accurate picture of the tonnage currently transported between locations in Britain and locations on the continent by type of commodity and by route used.

Each country-to-country exchange of freight for each commodity was analyzed separately and, based on the cost by alternate

2. Ferry gauge cars mean railway vehicles built to fit British and continental clearance gauges, whichever is less at any point on the cross section through the vehicle.

routes and information available from the sources mentioned, it was possible to estimate the allocations of the potential commodities. Assignments were made to the tunnel for various assumed levels of freight rate, and an optimum freight rate for each commodity was determined.

Many of the transport charges for the tunnel will be less than for the competing routes. The average charge per ton will be approximately $5.90 in 1965. Additional benefits to shippers may include—depending on the nature of the freight—faster delivery and reductions in breakage, spoilage, pilferage, insurance fees, and packing costs.

The total trade of the United Kingdom with the continental countries that will be served by the tunnel—Belgium, Luxembourg, Netherlands, Germany, France, Switzerland, Austria, Italy and Spain (the last named only as an exporter of fruits and vegetables)—amounted to 10,500,000 tons in 1957. Of this amount, 4,800,000 tons were exports from the United Kingdom and 5,700,000 tons were imports. Freight traffic to and from other European countries, such as Scandinavia, and to and from countries outside Europe, was excluded from an analysis of divertibility.

Of the total freight traffic analyzed, approximately two-thirds was found to be in bulk form and unlikely to be susceptible to diversion. The transport charges for most bulk shipments are so low that the tunnel would generally be unable to compete. Therefore, presently used routes would normally continue to be preferred by shippers and bulk freight was not allocated to the tunnel. Some portion of bulk shipments may be attracted to the tunnel, however, and revenues from such traffic would be over and above those mentioned by the consultants.

TABLE VI—1957 U.K. TRADE WITH AREA SERVED BY TUNNEL

Type of Freight	*Tons*		
	Exports	*Imports*	*Total*
Bulk—not potential	3,600,000	3,400,000	7,000,000
Other—potential	1,200,000	2,300,000	3,500,000
Total	4,800,000	5,700,000	10,500,000

With respect to the non-bulk freight which was considered potential to the tunnel, imports to the United Kingdom are approxi-

mately twice as large as exports. Of the non-bulk tonnage considered to be potential to the tunnel, it was estimated that approximately one-third would be diverted to the tunnel at the optimum freight rates for the categories of freight concerned. Table VI summarizes the potential and non-potential freight traffic.

Nearly 500,000 tons of freight a year, or fifteen percent of the total considered to be potential to the tunnel, is at present carried by the two rail ferries and the Tilbury-Antwerp road vehicle ferry.

Rail ferry services, as with passenger services, are virtually loaded to capacity during peak seasons, although a large part of the capacity is unused during the remainder of the year. Expansion of the present rail ferry facilities would require heavy capital expenditures for additional port facilities.

Use of the highway-ferry combination is a fairly recent innovation and offers great convenience to shippers. Offsetting this feature is the relatively high cost of the operation due primarily to the difficulty in arranging return loads for lorries in most continental countries.

A newcomer is bidding to penetrate the transport field. The container ship, a vessel designed or converted to handle containers of the type used on lorries or railway cars, combines to a significant degree the special advantages of the ferries with the economy of a cargo ship. Container ship services are at present operated between various U. K. and continental ports. The container movement represents a tunnel potential as piggy-back tonnage as well as a challenge to the tunnel in the form of competition from the container ship.

A large portion of freight traffic moves by the traditional method—road or rail to and from ports and liner or tramp steamer between ports. Virtually any size, shape and kind of cargo can be carried in a ship, and the transportation costs are low. Speed of transit compares reasonably well with ferry services. Furthermore, a ship is fairly flexible as to route and often is able to carry its cargo far inland (to Paris, for example). On the other side of the ledger is the high cost of handling and packing for many types of goods and, because a ship is a large unit, frequent service can be obtained only on the heavily used routes.

While the percentage increase in cross-channel air freight has

been rapid in the past decade, the proportion to the total of non-bulk goods, regarded as potential to the tunnel, is less than two percent.

Estimated diversions for 1965 and for the base year 1957 are shown in Table VII. It is interesting to note that the 1,167,500 tons allocated to the tunnel at 1957 trade levels is only slightly greater than twice the 500,000 tons now shipped on wheels across the channel by rail and highway vehicle ferries.

TABLE VII—FREIGHT TRAFFIC ALLOCATIONS—TONS

	1957		*1965*			
Category of Freight	*Potential Tonnage*	*Diverted Tonnage*	*Potential Tonnage*	*Diverted Tonnage*	*Average Charge Per Ton*	*Revenue*
Foodstuffs	1,236,300	346,800	1,571,800	386,200	$ 6.66	$2,571,000
Chemicals	487,000	187,000	467,400	172,000	5.01	862,000
Wood Manufacturers and Paper	231,500	38,800	263,000	55,700	4.67	260,000
Textiles and Wool	124,000	42,600	141,100	54,400	8.09	440,000
Mineral Manufacturers	860,000	252,400	769,800	223,600	4.62	1,033,000
Machinery & Equipment	264,000	159,300	325,700	199,900	9.49	1,898,000
Vehicles and Parts	131,700	63,900	105,900	51,100	12.82	655,000
Other Manufacturers	106,000	56,700	121,500	67,400	7.40	499,000
Mail	30,000	20,000	30,000	20,000	22.40	448,000
Total	3,470,500	1,167,500	3,796,200	1,230,300	$ 7.04	$8,666,000
Less Adjustment for Reduction of U.K. Mileage*					1.14	1,400,000
Balance					$ 5.90	$7,266,000

*Original calculations were based on a marshalling yard at Guildford instead of near Ashford as presently planned.

TOTAL REVENUES

Estimates of Channel Tunnel freight increases were based on projections of gross national product for the individual countries served and the estimated supply and demand for each type of freight carried. The freight tonnage is estimated to increase from 1,230,000 tons in 1965 to 1,707,000 tons in 1985. Based on an average charge per ton of approximately $5.90 in 1965 and approximately $5.60 in 1985, the estimated 1965 and 1985 freight revenue estimates are $7,266,000 and $9,579,000.

Table VIII shows total estimated traffic and revenues for the Channel Tunnel project for 1965 and 1985.

TABLE VIII—ESTIMATED TRAFFIC AND REVENUE FOR A RAILWAY TUNNEL UNDER THE CHANNEL

Item	*1965*	*1985*
Traffic		
Passengers	3,180,000	5,092,000
Vehicles	676,000	1,196,000
Freight (Metric Tons)	1,230,000	1,707,000
Revenue		
Passenger	$14,384,000	$23,030,000
Vehicle	14,736,000	26,256,000
Freight	7,266,000	9,579,000
Total	$36,386,000	$58,865,000
Percent of Revenue		
Passenger	39.5	29.1
Vehicle	40.5	44.6
Freight	20.0	16.3
Total	100.0	100.0
Weighted Average Toll		
Passengers	$ 4.52	$ 4.52
Vehicles	$21.80	$21.95
Freight (Metric Ton)	$ 5.90	$ 5.60

Tunnel Feasibility: English, French, and American investors have compared the estimated revenues with the estimated construction, maintenance and operating expenses for the various alternate tunnel schemes. They believe it is economically feasible to construct the Channel Tunnel.

Correlation of Expressway Planning With City-Street Planning

FREDERICK T. ASCHMAN

Mr. Aschman of Barton-Aschman Associates, engineering and planning consultants, formerly served as Director of the Chicago Plan Commission and as Director of the Cook County Housing Redevelopment Agency. He is a Lecturer in City and Regional Planning in Northwestern University's Department of Civil Engineering and Chairman of the Planning Committee of the North Eastern Illinois Metropolitan Area Planning Commission.

GIGANTIC freeway programs launched in the 1950's captured the public eye. This public attention is warranted on the grounds that massive effort is needed to meet mounting traffic demand.

Will the big push for rapid completion of freeway networks mean neglect of other segments of the metropolitan street system? If the answer is affirmative, as in some cities, it is easy to understand why.

Few will quarrel with the value of well-planned freeways. They are great engineering accomplishments, and their high-capacity and safety characteristics usually more than offset the cost. They meet the need for high-volume, high-speed movement over fairly long distances. Planned in a system, they offer the metropolitan population new efficiency in this kind of movement, and they open new opportunity for a range of choice in employment, enterprise, and cultural activity.

Along with these legitimate aspects, however, the freeway has something else—driving appeal. The public sees progress in the swinging demolition ball, the fleets of road-builders' equipment, ribbons of fresh cement or asphalt, the dedication ceremonies, and the opening to a parade of traffic.

The freeway is thus easier to accomplish than traditional types of arterial street improvement. And local governments feel they are getting more for their money in freeway development than in arterial improvement.

If these reasons, valid and whimsical, help explain the professional, public, and political support for emphasis on freeway programs, they cannot on the other hand justify it to the extent of neglect of other elements of the metropolitan street system. While it may be granted that there is only so much money to spend—an arguable point—it could well be that economic losses from such neglect could outweigh the benefits of the fastest possible freeway development.

EMPHASIS ON CAPACITY AND HIGH SPEED

Much traffic planning emphasizes the ability of the freeway to move large volumes of traffic rapidly. It has been remarked that the freeway represents the ultimate in adaptation of the highway to modern automobiles. This seems to say it is the duty of planners to keep up with the designs on Detroit drawing boards rather than to work for an efficient, livable city.

This type of practice runs counter, of course, to theory. Looking toward a balanced street system, the national committee on urban transportation suggests as a prerequisite to the design of the system a thorough understanding of the function of the different types of street in its basic categories.[1]

This is tantamount to saying that street planning—and, of course, street programming as well—should consist of a broad approach, carefully mapped out on the basis of comprehensive study that identifies the separate but related and often overlapping roles of the freeway, the arterial highway, collector-distributor streets, and local service streets. It implies that this planning and programming must be based on knowledge of the total urban structure.

Violation of this theoretical injunction obviously can produce dire effects regardless of which element is over-emphasized or neglected. Since we are concerned here with current tendency, let us examine the possibilities if the great bulk of highway allocable to any given metropolitan area were to be devoted largely to freeway development to the point of minimizing or ignoring other types of street improvement needs.

First, there is the danger of minimizing the value of the freeways

1. National Committee on Urban Transportation, *Better Transportation in Your City*, Public Administration Service, Chicago, 1958. p. 42.

themselves through failure to carry out improvements in complementary or supplementary elements of the system. Assembly and distribution are obviously as much a part of the trip as the long haul, as is the ever-present problem of terminal storage.

Second, there is the question of effects on metropolitan growth patterns. Mitchell and Rapkin[2] point out that the "processes by which various land-uses sort themselves out in the urban pattern are in large measure a function of the movement-requirements of establishments." It is, of course, true that legitimate public policy may foster further decentralization or diffusion by means of freeway development that may widen the distance gap without loss of efficiency in the relationship of various specialized metropolitan functions.

Yet no single element of the total street system, be it freeway or arterial or local street, can serve the locational requirements of all kinds of enterprise or social activity. An implication of imbalance is thus clearly one of denial of locational amenity to many establishments that may seek new locations in the process of metropolitan growth and distribution.

Third, there is the matter of conservation or even survival of existing uses. Hardly a functional element of the urban area today has escaped the need for adjustment to increased automobile usage. Neighborhoods and business and industrial districts require relief from the intrusion of through-traffic, and they often depend for their continued well-being upon adjustment or re-working of their designs to accommodate the automobile.

It is true that freeway development may remove much traffic pressure from such districts by virtue of the attraction of traffic to the new high-capacity, high-speed facility. So much is to the good, but it is unlikely that any metropolitan freeway system will bring all the relief necessary. A real need is for specialized street re-design as part of the modernization of existing land-use districts. And, at the minimum, there is substantial need to improve intra-zonal and short-haul inter-zonal movement in many urban areas.

Fourth, there is the potential of urban renewal as an organized program having national objectives. These objectives are based not

2. Robert B. Mitchell and Chester Rapkin, *Urban Traffic—A Function of Land Use*, Columbia University Press, New York, 1954. p. 132.

only in the important need for elimination of substandard urban conditions but also in the long-run need for re-design of the urban structure and the establishment of an orderly "metabolism" of development and redevelopment.

The role of street planning and programming is increasingly being recognized as a key element in this potential, and, more importantly, this role is seen only in the context of its being a balanced one. This is to say, conversely, that failure to move equitably in street planning and programming will be to invite failure as well in the vital urban renewal effort.

If these are predictable areas of effect of possible neglect of any elements of the street system, the specific means of avoiding them are not yet clear. It is one thing to sound a negative warning against imbalance in programming. It is an improvement to urge in generalities the balanced approach. What is needed most, however, is a transportation study in depth, a study that will combine the new scientific techniques being developed in current area surveys with broader comprehensive planning programs.

Transportation planners have been seriously handicapped by the inadequacy or even absence of local city planning programs that might be expected both to project a comprehensive view of developmental objectives and to provide intimate knowledge of the functional needs of major metropolitan land use elements.

Local governments, and their traffic engineers and planners, have on the other hand been handicapped by an inability to match freeway planning funds and by the relative remoteness of area transportation study staffs from the realm of overall policy development.

SPECIFIC NEEDS FOR CORRELATION

Several kinds of results might, on the basis of current experience, be expected from a more thorough involvement of highway planning in the planning of total community growth.

The most striking of these possible results could well be those approaches that would undertake to project basic changes in city form and structure. Major freeway development obviously represents one of these approaches, for construction of such arteries can be based on deliberate forcing of desirable structural changes. Per-

haps a more interesting approach would be to use a variety of thorofare-improvement devices to promote new or altered land forms.

One such multi-faceted approach is being explored by Chicago traffic engineers and planners. While recognizing the need for basic freeway networks, they are highly sensitive to maintaining and strengthening inner-city land uses whose movement requirements cannot be served exclusively through high-capacity, high-speed arteries.

The Chicago investigation hypothesizes that the structure of the city can be treated, not radically but nonetheless effectively, through building upon existing high-concentration, highly-congested "corridors" of intense land use that originally grew out of the pattern of rail and waterway development. The corridor activities are, by definition and in fact, high traffic generators and by nature compatible with high traffic concentration.

They may include industrial, commercial, high-density residential, and institutional and other uses. The experimental objective is to bulwark these corridors by creating improved routes, usually at the edges of the elongated district, to allow for moderate-to-high speed arterial movement while utilizing major streets in the core of the corridor for local access or specialized transit or trucking facility.

The hypothesis of this particular idea anticipates the co-ordinated application of highway funds, urban renewal programming, and land use controls and incentives to purify this existing land form. Valuable uses would be preserved. More significantly, the corridor district would offer new locational amenity for uses that may ideally require in-city sites but ordinarily would shun a high-concentration area because of accompanying congestion. By employing on a continuous basis the newer devices of urban renewal and perhaps some yet-to-be-developed legal mechanisms, this kind of planning may well produce a lasting type of regenerative land form.

On another administrative front, an implication of co-ordinated highway and general planning almost certainly will be the integration of thorofare improvement with urban renewal. Traffic planners have properly complained of the demands placed upon them by renewal planners whose projects often require extensive expendi-

ture of highway improvement funds considered by the traffic element to be more urgently needed elsewhere. It is naturally difficult for custodians of these funds to accede to pressure to devote money to the rearrangement of traffic patterns in order to accommodate renewal projects. A logical answer to these complaints might well be two-fold.

First, it would be highly advantageous for the urban renewal program and the highway improvement program to be so correlated that they serve mutual or complementary aims. There is no dictum that requires a renewal project to encompass geographical areas on a land unit basis alone. Projects may, with co-ordinated pre-planning, be designed to correct circulation problems as well as to replace obsolete land uses. Thus they may be utilized to eliminate congestion from various trouble spots in blighted areas, and even to provide through-stage programming for the development of new rights-of-way over considerable distances.

Second, it is reasonable to aim for creation of special additional funds to enable off-site highway improvements required as a result of urban renewal project planning. A more thorough involvement of both highway planning and renewal planning in the general planning process would undoubtedly make this need clear.

Closely related to the matter of "balanced" programming of highway funds is also the special problem of the various types of business districts that represent tremendous investments and tax resources in built-up areas.

The newest form of shopping facility is, of course, the center in outlying areas. It is one of the chief beneficiaries of large-scale freeway development. This form of shopping district is highly legitimate and proper in the metropolitan scheme of things. Yet an imbalance in freeway programming and center development has serious implications for competing in-city retail districts. Failure to modernize the in-city district, especially in traffic terms, can thus lead to needless deterioration of markets already affected by the newer developments.

While downtown interests are often among the foremost advocates of heavy freeway development, the needs of downtown include to a very marked degree a series of other types of highway improvement. The most obvious example is the plight of central business

districts that will be served by new expressways without concomitant development of distribution facilities. The probable result will be a terminal congestion minimizing, even offsetting, the advantages of a high-speed expressway haul. Other downtown needs almost invariably include the necessity for by-pass routes to accommodate through traffic and thus remove many if not most conflicts in types of movement on business streets.

Major existing "middle-aged" middle-belt retail districts usually have similar problems, the solution of which may demand balanced programming of highway improvements. Many studies of such districts have indicated that their modernization depends in major part upon arterial improvements that will remove congestion caused by the conflict in purpose: through-movement versus local circulation.

Other kinds of business districts usually have proved to be the step-children who are too often given up for lost because they apparently have been rendered obsolete by technological change. One of these is what has been called the arterial hierarchy.[3] This is the familiar strip commercial district that may serve a variety of specialized community purposes but also hampers, and is hindered by, traffic movement on the major thoroughfares along which it is often situated. Often unsightly yet frequently valuable as a legitimate use district, this type of area calls for re-working in the form of specialized highway improvements and related renewal design.

CO-ORDINATION OF FEDERAL-AID PLANNING

This list of functional areas could, of course, be expanded until it includes virtually all of the major groupings in the metropolitan area. Medical districts, university areas, large industrial districts, and various types of living areas will depend for their long-term stability on comprehensive planning in which highway planning is a particularly strong element.

Although highway engineers and city planners have shown steadily-increasing interest in co-operative development of comprehensive area plans, the most significant statement of recent years has been the dual issuance of HHFA-Department of Commerce

3. Garrison, et al., *Studies of Highway Development and Geographic Change*, University of Washington Press, Seattle, 1959. p. 125.

"Joint Policy and Procedural Statements on Improved Co-ordination of Highway and General Urban Planning."[4]

While couched in cautious procedural terms, the Federal statements announce a formal approach to the kind of coordination of Federal and local planning expenditure that has been undertaken informally in some areas. Under this plan, the agencies would allow joint financing of a "co-operative and comprehensive approach to metropolitan area development" through Federal-aid highway funds and HHFA urban planning grants.

To be sponsored on an experimental basis by state highway departments and state, metropolitan or regional planning agencies, the formal co-ordination would be designed to:

a. Give consideration to all forces, public and private, shaping the physical development of the total community.

b. Cover land uses and controls as well as plans for physical development and combine all elements of urban development and redevelopment into a clear-cut, comprehensive plan of what the citizens want their community to become.

c. Cover the entire urban area within which the forces of development are interrelated.

d. Involve in the planning process the political jurisdictions and agencies which make decisions affecting development of the metropolitan area.

e. Link the process of planning to action programs.

The great hope that this combination of federal planning aid suggests is that it will lend real mechanical facility to the establishment of thought-through philosophies of street and highway planning in combination with clear directions for the future derived from general city planning. If co-ordination in planning is to be more than collaboration in physical design without theoretical development, the combined program must involve the following thorofare-planning questions:

"How can the development of thorofares contribute to the stabilization or re-creation of urban values? Is the stabilization or enhancement of these values dependent on thorofare development? Are the interests of the city and its suburbs identical or conflicting? How can the different types of

4. Housing and Home Finance Agency and U.S. Department of Commerce release, November, 1960.

roads comprising the system be classified? What are the basic differences in role or function?

"What level of transportation service (speed, quantity) should be provided by the system? How is this related to the growth pattern of the metropolitan area?

"What physical shape can thorofares take to provide appropriate transportation and at the same time make the optimum contribution to urban development? Within what time limits are what right-of-way widths feasible? What factors place limitations on ultimate right-of-way widths? Do all thorofares require complete continuity across the city?

"What policies regarding mass transportation should be accepted, as policy decisions are made in regard to the level of service by motor vehicle?

"What should the target date for thorofare planning be? Can land planning in new areas and renewal planning for older areas proceed in the absence of a definitive thorofare plan? How frequently in the history of city's evolution can the thorofare system be significantly reorganized?

"Is the target date in planning a system of *rights-of-way* different than the planning limit for *improvements* within those rights-of-way? Should right-of-way be viewed as basic transportation corridor without attempting to predict exactly the mechanical nature of the transportation?

"What kinds of revisions in the local street system to protect communities can accompany thorofare development?

"How can a balance between needs and resources be identified? Can new financing methods be conceived?

"What legal obstacles need to be overcome to permit thorofare development?

CONCLUSION

It is not intended here to deprecate the expressway as a dynamic and vital element in metropolitan development. This is not to suggest or even imply the desirability of slowing down such key work as that of advancing completion of the interstate system.

What is increasingly being seen as an urgent goal is the relating of the form of highways to the functions of the urban area and the programming of highway funds on the basis of carefully-derived priorities.

Many administrative questions are involved in achieving this goal. Present and projected revenue resources may not be adequate, so that new forms of financing may need to be developed. The

governmental hierarchy may require streamlining, or, at the very least, there must be more effective liaison established in the policy-making process in metropolitan areas.

Interprofessional relationships and the exchanging of views may need to be maximized, so that highway engineers make increasingly important contributions to comprehensive city planning and city planners in return contribute more substantially to highway planning.

Yet, however difficult the question may be to answer, the future of cities is being shaped both by action and inaction on the planning level. It is important that the action be sound and that areas of inaction be eliminated through comprehensive effort.

$529,700,000 Rapid Transit System Recommended for Los Angeles

PHILIP M. LINSCOTT

Mr. Linscott is Director of Traffic Engineering for Welton Becket and Associates. His previous experience includes work as Chief Transportation Engineer for Daniel, Mann, Johnson, and Mendenhall, a Los Angeles firm of architects and engineers; Traffic Engineer for De Leuw, Cather and Company, Consulting Engineers. He directed the planning of the rapid transit facilities for the $529.7 million, seventy-five-mile system for Los Angeles. He was Project Manager for the $41 million Chicago Parking Program, the $46 million Lake Pontchatrain Causeway, and the $17 million Cincinnati Parking Program. He holds degrees in Aeronautical Engineering (Structures) and in Civil Engineering (Traffic and Transportation). He is a member of the Institute of Traffic Engineers, the American Society of Civil Engineers, and the American Public Works Association.

THE Los Angeles Metropolitan Transit Authority was established in 1951 by an act of the California State Legislature to assist in the development of modern mass transit facilities. Severe limitations on service area and type of equipment made the initial act ineffective.

In 1957, basic changes to the 1951 act granted the authority right to operate a network of mass transportation facilities and charged the Authority with responsibility to ascertain the need for and proceed with development of required rapid transit. The limitations on service area and equipment were removed.

In 1958, the Authority sold revenue bonds and purchased the two principal operating transit properties in Los Angeles. The Authority was in business. And for the first time in thirty years an improved public transportation system appeared probable.

No basic disagreement exists among transportation engineers concerning the need for a modern, high speed, high capacity, efficient system of moving people within our major metropolitan areas. Reports dating from 1952 describe the Los Angeles area as one "requiring a system of trunkline rapid transit lines to assure the

continued growth and prosperity of the area." There has been controversy, however, over: What constitutes an adequate transportation system? How should it be financed? and Who should be responsible for planning an area-wide system?

Unfortunately these questions are not resolved, although developments point to improved co-ordination of city, county, state and LAMTA activities. This article is necessarily limited to the first question stated above, with particular emphasis given to the justification for including rapid transit as part of an efficient transportation complex.

TRANSIT NEEDS STUDY

In 1958, the LAMTA contracted with a consulting engineering firm to survey the general pattern of transit use and the need for rapid transit facilities in the Los Angeles area. This survey was completed in May, 1959. The report delineated twelve principal travel corridors radiating from the central city area to all sectors of the Los Angeles basin.

Of these twelve corridors, these four were selected for further evaluation: Wilshire corridor extending from the central city area of Los Angeles to Santa Monica; Reseda corridor which follows the line of Wilshire corridor to approximately Highland Avenue and then through Cahuenga Pass into the San Fernando Valley to Reseda; the San Bernadino Corridor, which extends easterly to Covina, and the Long Beach corridor which extends from the central city area to Long Beach. Preliminary projections of traffic and revenue potential indicated that further detailed engineering evaluation was justified.

PRELIMINARY ENGINEERING

In November of 1959, the LAMTA moved into the second major phase of engineering studies, and commissioned a Los Angeles firm of architects and engineers to determine: What shall we build? Where shall we build it? (within the four selected corridors) and What will it cost?

The engineering investigation was divided into two phases: (1) a broad evaluation of possible transit systems and alignments and the selection of a limited number of alternates for detailed study

and (2) comparative analysis and definitive engineering of the several alternates so that costs and advantages and disadvantages could be compared.

TRANSIT EQUIPMENT

The evaluation of rapid transit equipment and system configurations comprised one of the principal efforts during the initial phase of the rapid transit program. The changing pattern of land-use, population density, and mass transportation efficiency in the Los Angeles metropolitan area indicated need for a complete review of rapid transit technology and the selection of a system configuration to satisfy the need for a system to augment and compliment the freeway network.

Accordingly, an active search was carried out to find new concepts of mass transportation. This search produced a number of systems to be evaluated and finally screened to a limited number for detailed investigation.

The first step in the evaluation process involved development of basic criteria for a mass rapid transit system for Los Angeles. A set of minimum requirements covering a broad range of functional factors was used effectively in the initial screening of transit system proposals. It was determined from preliminary planning studies that the transit equipment must be capable of speeds of up to eighty miles an hour with average speeds of from thirty-five to forty miles an hour depending on the spacing of stations and the duration of station stops.

These speeds provide a comfortable margin over the freeway peak-hour speed capability. The system further was required to provide for 30,000 passengers an hour in order to have adequate capacity. Factors of convenience, comfort, safety and aesthetics were added to complete the transit criteria.

The screening of systems started with a series of hearings and presentations wherein various manufacturers, inventors and proponents were encouraged to submit their ideas on transit systems. Some fifty individuals or firms were heard and almost every conceivable form of transportation ranging from helicopters to moving sidewalks was considered. Of all the many systems reviewed only one proposal involved use of a new concept as applied to mass

transportation. This was the proposed use of an air cushion for vehicle support, rather than wheels.

The evaluation of these proposals resulted in three system types being recommended for detailed study and comparative analysis. These were: The conventional dual track system; supported monobeam, commonly called saddlebag monorail; and the split rail symmetrical suspended monobeam system.

In carrying out a detailed comparative analysis of the three systems, it was necessary to make a field survey of existing operating systems. Trips were made by staff members to selected installations in North America and Europe to inspect and review the operation of critical components under service and test conditions. Studies were made of switching mechanisms, operation and control devices, guidance systems and safety features.

Finally, preliminary designs were prepared for the three systems incorporating modifications necessary to meet the Los Angeles requirements and putting them on a comparable basis for cost estimating purposes.

Special investigations were carried out to determine the feasibility of using rubber tires to improve grade climbing ability and reduce noise. These studies indicated that rubber tired vehicles would be able to negotiate steep grades with ease, would emit fifty percent less noise than steel wheels and would permit a substantial savings in weight over conventional transit cars.

During the comparative analysis of the three systems, both functional and cost factors were used. The results of this investigation showed that from a functional standpoint, any one of the three systems could be applied to Los Angeles. However, the cost analysis revealed the supported dual track system to be the least expensive of the systems to build and maintain. Further, the dual track supported system provides the most advanced status of development even with modifications involving use of rubber tires and special safety devices, considering the extensive use of similar vehicles in the Paris subways.

During the early stages of this study, many concepts of mass transportation service were proposed and rejected as not meeting various points of established criteria. The most ambitious of these plans was conceived by an engineer-economist in Los Angeles.

This proposal involved the development of a full coverage grid system of underground rapid transit lines, each line to operate in one direction and spaced at one-mile intervals. Interconnecting loop trains would provide for transfer between east-west and north-south pairs of one way lines, and through electronic control and synchronization no waiting at transfer points would be required.

SERVICE CONCEPTS

While the concept is interesting, the cost appears beyond the financial capability of the community. Preliminary estimates indicate that the full coverage system serving the Los Angeles metropolitan area would cost nearly thirteen times as much as the recommended 150-mile eight-corridor master plan of trunk-line rapid transit.

Other service concepts rejected for not meeting established criteria included a full motor bus system, the use of low passenger capacity monorail or subway systems and the use of large helicopters.

The answer to question number one, What shall we build? was formulated after due consideration of the types of areas to be served, the physical problem along several alternate alignments studied in the four corridors, and following the comparative analysis of systems and equipment.

METRO SYSTEM RECOMMENDED

The system recommended was called the metro system to denote its applicability to metropolitan transit service. Metro is conceived to be the fastest, lightest weight, and most comfortable transit system in the United States. The cars would incorporate modern design, run on rubber tires, and be equipped with light weight steel auxiliary wheels for safety and switching with conventional rail switches.

Positive guidance would be provided by horizontal guide wheels riding on center guide rails. Insurance against derailment would be provided by an uplift stop riding between uplift channels incorporated with the center guide flanges. An artist's conception of the cars operating on an elevated section is shown in Figure 1.

The cars would be fifty-four feet long, ten feet wide, and twelve

feet high from top of track to top of car and would operate in trains of from two to six cars. The cars would be air-conditioned, of lightweight design using air-frame manufacturing techniques. They would seat fifty-four passengers and carry sixty-six standees without over-crowding. Three sets of double doors on each side of the car would facilitate loading and unloading of passengers and would permit either center or side platform loading. The cars would have end doors for emergency use.

TRAIN CONTROL AND OPERATION

Metro trains would be capable of speeds of eighty miles an hour and would accelerate and decelerate at 3.5 miles an hour per second under normal operation. Six hundred volt direct current traction power would be used with four 125 horsepower electric motors a car. Power would be supplied to trains by means of a contact rail with a negative return which would not be grounded except at substations. Dynamic braking would be used in conjunction with disc brakes which would permit emergency decelerations of as great as 4.5 miles an hour a second.

High-speed operation as proposed for this system would require automatic control. Full automatic operation is desirable for a completely safe system. Accordingly, a fail safe automated system was designed. It incorporated central train control with a programmer, central computer, wayside control unit and train control unit.

While the system is capable of unattended operation, one attendant would be carried in each train for security and psychological reasons. With the recommended system, headways of less than 90 seconds can be safely maintained, and with one mile station spacings and 20 second station stops, average speeds of from thirty-five to forty miles an hour can be maintained.

ALIGNMENT AND WAY STRUCTURES

The type of way structure on which the recommended equipment would run was given study from the standpoint of providing surface, overhead, or subsurface structures. Various types of tunnel construction procedures were given detailed study by a tunnel consultant. The overhead way structure would consist of two monolithic beams supported at intervals of 100 feet to 110 feet by single columns.

Figure 1. Artist's concept of city street with overhead structure of the Metro rapid transit system recommended to Los Angeles Metropolitan Transit Authority.

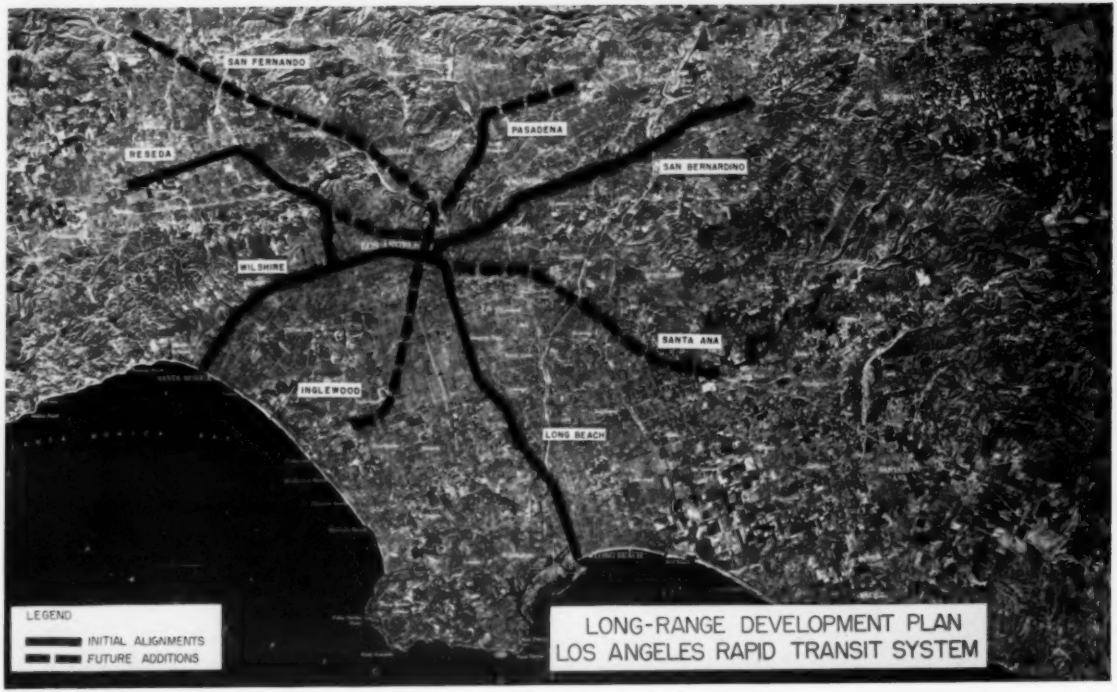

SAN FERNANDO
PASADENA
RESEDA
SAN BERNARDINO
WILSHIRE
SANTA ANA
INGLEWOOD
LONG BEACH
LEGEND
INITIAL ALIGNMENTS
FUTURE ADDITIONS
LONG-RANGE DEVELOPMENT PLAN
LOS ANGELES RAPID TRANSIT SYSTEM

Figure 2.

The surface configuration would consist of two concrete beamways. The structural aspects of the various configurations were studied in order to provide structures with minimum dimensions and still maintain a completely safe structure under all possible operating conditions. These various studies determined that cost of overhead construction would be in the order of one-half the cost of subway construction in outlying areas, and further that overhead construction would be approximately one-third of the cost of subway in a central business district.

As a result of this cost comparison, coupled with a general directive from the transit authority to develop a transit system most economical to build and operate, recommendations were made for principally overhead construction except where possible to construct at grade. In the initial 74.9 miles of recommended routes, some fifty-one miles were recommended for overhead construction, 21.6 miles for at-grade, and 2.3 miles for construction in tunnel.

As previously noted, the transit authority was advised to give detailed study to four corridors, believed to be most likely to support a rapid transit facility from an economic standpoint. The principal study effort concerning alignment selection, station location evaluation and other matters pertaining to mass transportation service was directed toward the four-corridor system, which can also be generally termed a trunkline-feeder service concept. Parallel with this principal effort, however, a study was given to both the flexible system utilizing buses throughout, and the full-coverage system.

While only a limited effort could be expended in the evaluation of the flexible and full coverage systems, studies were carried far enough to determine that the flexible system could not, in the Los Angeles situation, provide transit service sufficiently attractive to lure the present automobile driver from his automobile to buses even in periods of heaviest traffic. It was further determined that the full-coverage concept would require such heavy expenditures of funds for way structures that it would be entirely beyond the capability of the transit authority of the community to support such a facility. As a result of these studies, the consultants reached a conclusion that the trunkline-feeder service concept would best serve transit patrons in the Los Angeles area.

As studies of alignments progressed and a plan for a comprehensive system of mass transit began to take form, it was deemed neces-

sary to arrive at a long-range development plan that would encompass more territory than that served by the initial four corridors. Therefore, additional attention was given to the engineers survey report concerning the twelve corridors established as principal routes of travel. As a result, a total of eight corridors were selected to provide rapid transit service to all principal sectors of the Los Angeles area.

This eight corridor plan is shown in Figure 2. It was further deemed necessary to make recommendations for long-range planning in order to adequately account for the intersection and interchange of the various lines in the Los Angeles Central City Area. This work resulted in a plan providing for direct service or one transfer connections between all corridors.

The Los Angeles central city area, by virtue of its position at the junction of the corridors, is the heart of the transit system. The planning analysis of service to and through the central city showed the necessity for providing both main line service and supplementary secondary passenger distribution within the central area in order to provide needed station coverage. Initially, the secondary distribution could be provided by a system with buses operating on exclusive bus lanes.

Ultimately, a fixed grade separated lightweight transit system is envisioned to distribute passengers and relieve sidewalk congestion. The system would operate at fifteen miles an hour, and would have stations spaced at approximately 600 feet apart. The secondary system would be designed to conveniently connect with the primary main line systems.

Several corridor alignment alternates were worked out in the initial four corridors and then by cost and service comparison, the recommended alignments were chosen. Major *park'n ride* stations are proposed in each corridor to facilitate the collection of passengers. Stations within the corridors were, where possible, coordinated to connect with the Authority bus lines which would serve as feeders and distributors.

The estimated cost of the initial 74.9-mile section of recommended rapid transit facility totals some $529,700,000.00. A breakdown of this estimate is shown in Table I. All of the items pertain to the mainline system except Item 7. This is an additional facility some five miles in length which would provide for distribution of

passengers in the central city area. Such a facility, termed the Carveyor System, has been proposed.

The secondary distributors would carry from 7,000 to 10,000 passengers an hour, each car seating from six to ten passengers. The system would operate at approximately fifteen miles an hour, would be fully grade-separated and would interconnect with downtown rapid transit stations to extend the service area of such stations.

SYSTEM COST

During the course of the engineering studies, it was generally conceded that there was no question of the necessity for the development of rapid transit facilities in the Los Angeles area. However, its timing of development will hinge on the ability to finance the system, a problem now being given serious consideration by the transit authority.

TABLE I

SYSTEM COST ESTIMATE—74.9 MILES

1.	Structure and Road Bed	$155,900,000
2.	Stations	$ 41,800,000
3.	Electrification	$ 51,900,000
4.	Control and Communication	$ 20,600,000
5.	Utility Relocation	$ 18,000,000
6.	Yards and Shops	$ 7,600,000
7.	Secondary Distribution System	$ 20,800,000
8.	Land Acquisition and Right-of-Way	$ 26,400,000
9.	Rolling Stock	$ 75,900,000
	TOTAL (1960) Cost	$418,700,000
	Administrative and Professional (Est. 10 percent) To include engineering, surveying, sub-surface explorations, construction, supervision, testing and inspection, management and administrative and Operation Start-Up	$ 41,900,000
	Plus Reserve for Contingency at 15 percent	$ 69,100,000
	TOTAL SYSTEM COST (1960)	$529,700,000

ECONOMIC OUTLOOK

The Los Angeles firm's recommendations, submitted in June 1960, were followed by a more complete summary of findings in September 1960. With the questions of what, where, and at what cost answered, the Authority turned to the important problem of *How*?—How to finance, How to obtain right-of-way, and how to

gain public acceptance of a rapid transit system. All are basic to the ultimate success of the transit program.

In December 1960, an up-to-date evaluation of the economic potential of the recommended 74.9 mile system was submitted. In brief, the report indicated the system to be economically feasible, but not profitable enough to use revenue bonds as a financing medium.

As this article is published the California State Legislature is considering various proposed changes in the LAMTA act. These changes are so basic with regard to the process of right-of-way acquisition, financing methods and other factors, that passage may insure early development of the rapid transit system, while negative action may completely derail rapid transit planning for many years.

WHY RAPID TRANSIT?

In this and in most major projects that involve public agencies, private property and in particular, public transportation, there is opposition. Fortunately, most of the tangible objections to rapid transit, such as difficulty in obtaining right-of-way, high noise levels and cost are rather easily answered and overcome. However, certain special interest groups present various intangible arguments which are subject to differences of opinion.

Reference has been made to the efficiency of the freeway, comparing it with operation of obsolete rapid transit systems. Due consideration has not been given to the great benefit which can derive through a proper combination of rapid transit and freeways, or to the actual efficiency of the recommended rapid transit system for Los Angeles.

Doubt is cast on the LAMTA contention that home-to-work trips are best served by high speed rapid transit trains in which the commuter may read, relax or continue with paper work from his office. Attempts have been made to re-define the term *rapid transit* to introduce the automobile, and the motor bus as a modern form of rapid transit.

These efforts are only as successful as the audience is gullible or uninformed. It appears necessary that the LAMTA undertake an extensive program of public information to set forth economic advantages of a total transportation complex that includes, in addi-

tion to local streets, arterials and freeways, the vital component of rapid transit. The elements of success for the rapid transit plan are inevitably a part of the present traffic muddle—the growing realization that high peak demands for home-to-work transportation cannot be handled by automobiles alone—that continued expansion of the Los Angeles economy will not be possible without more adequate home-to-work transportation and the staggering cost of transportation to the individual.

The Los Angeles metropolitan area has developed at a rapid pace—from 1,000,000 people in 1920 to the second largest metropolitan area in the country in 1960, with a population of 6,742,000. Most of this growth has occurred with transportation planning centered about use of the automobile, and the area is now dependent on the freeways for circulation.

Present construction of additional freeway links, and even the multi-billion dollar master plan of freeways projected for completion by 1980, are not expected to materially relieve the increasing traffic congestion brought about by growth in population and vehicle registration.

It is evident to all key city, county and state officials that a high capacity rapid transit supplement to the freeways must be developed to enable the freeways to perform the transportation job they have been designed for. The price tag of $529,700,000 for the first 75 miles of a rapid transit system is low, considering the part that such a system can play in solving the overall transportation problem in the Los Angeles Area.

Motor Vehicle Pollution Control

JOHN T. MIDDLETON AND DIANA CLARKSON

Professor John T. Middleton, Ph.D., is Professor of Plant Pathology and Chairman of the Department of Plant Pathology at the University of California, Los Angeles and Riverside, and chairman of the University Committee on Research in Air Pollution and is a consultant to the Los Angeles County Air Pollution Control District. He is a member of the California Department of Public Health's Air Sanitation Advisory Committee and the Technical Task Group for Automobile Exhaust Research of the U. S. Department of Health, Education, and Welfare. He served as advisor on air pollution to the governments of Chile, Canada, France, and Spain. He is Chairman of the State of California Motor Vehicle Pollution Control Board.

Diana Clarkson is Secretary of the State of California Motor Vehicle Pollution Control Board. Previously she served as Consultant to the Assembly Interim Committee on Public Health of the California Legislature. Her activities with this committee included air pollution legislation and the development of Assembly Bill 17 establishing the Motor Vehicle Pollution Control program in 1960.

AIR is a natural resource essential for man's health and well-being. Today this air resource is being destroyed in many parts of the country. Air pollution, occurring most often in and adjacent to urban areas, results from the discharge of waste materials produced by our complex industrialized society.

This community-air-pollution interferes with visibility, irritates the senses, adversely affects health, and damages property.

Sources and amounts of air pollution have changed as our society has changed concomitant with increased fuel consumption required for economic and social improvement. California has considerably progressed in the control of stationary industrial and domestic sources of air pollution resulting from the refining of petroleum, conversion of organic fuels to electricity, production of goods, and the disposal of organic wastes.

The signal success of the first air pollution control district formed in Los Angeles in 1947, with the growth of community air pollution in California, inspired the activation of six additional air pollution control districts. These districts embrace seventy-nine percent of

the state's total population comprising twelve of the state's fifty-eight counties. Significant gains have been made by all of these districts in controlling pollution from stationary sources. These gains, however, have been largely offset by contamination of the air from motor vehicles.

California became the first state to establish a program for control of motor-vehicle-created air pollution when the legislature, at a special session called for this purpose in 1960, enacted Assembly Bill 17. Passage of this bill, often called the Cameron bill after its principal sponsor, was possible because of the growing body of technical knowledge indicting the motor vehicle and especially because of the demands for control made by an aroused and concerned public.

This bill extended the state's role beyond its traditional one of assistance and research to local governmental agencies by assigning it responsibility for direct control of pollution from motor vehicles. The Cameron bill created the motor vehicle pollution control board for the purpose of developing the state motor vehicle pollution control program, which will have a profound impact on the evolution of control programs in other states, the automobile industry, and the motoring public.

THE MOTOR VEHICLE AND AIR POLLUTION

The significance of the motor vehicle as a major contributor to community air pollution has been well documented. It has been estimated that the automobile emits into the atmosphere the following pollutants for each 1,000 gallons of gasoline consumed[1]:

Carbon Monoxide, 3,200 pounds; Organic Vapors, 200-400 pounds; Oxides of Nitrogen, 20-75 pounds; Aldehydes, 18 pounds; Sulfur Compounds, 17 pounds; Organic Acids, 2 pounds; Ammonia, 2 pounds; Solids (Zinc, Lead, Other Metallic Oxides, and Carbon), 0.3 pound.

In Los Angeles County, the more than 3,000,000 motor vehicles each day pollute the air with 1,450 tons of hydrocarbons, 440 tons of nitrogen oxides, and 8,990 tons of carbon monoxide.

1. Chambers, Leslie A. Transportation Sources of Air Pollution, Comparison with Other Sources in Los Angeles. Proceedings, National Conference on Air Pollution, U.S. Dept. Health, Education & Welfare, Washington, D.C., p. 168, 1958.

Some components of motor vehicle exhaust are known to be harmful in the form in which they are emitted, while others are harmful only after they have reacted in the atmosphere and have formed new compounds that characterize community-type air pollution. Carbon monoxide is an exhaust component harmful in the form emitted. This noxious gas is known to be toxic when exceeding certain levels. For this reason, maximum levels to which workers in industry can be exposed have been established.

The importance of the motor vehicle in adding to atmospheric carbon monoxide levels has been shown in metropolitan traffic and tunnel studies and in a more than fifty percent increase of the concentrations of carbon monoxide in Los Angeles County between 1955 and 1959 as car population has increased.

Organics, including hydrocarbons and the oxides of nitrogen emitted by the motor vehicle, are important since, unlike carbon monoxide, they are compounds that react in the atmosphere in the presence of sunlight to create the health-damaging, property-destroying, visiblity-reducing manifestations of photochemical or community air pollution.

One study indicated a relationship between the use of high octane fuel and plant damage and established that under certain climatic conditions, the threshold level for plant damage from photochemical oxidation of raw, unburned gasoline as well as partially combusted gasoline is 12 tons per day per square mile.[2]

The influence of these emittants on the problem of air pollution in a particular area is not determined solely by weight. Rather it varies depending upon several factors including wind and its ability to disperse the pollutants, on geographical and climatic conditions, and on the reaction rate of the various pollutants themselves.

Although it is not possible to state with precise accuracy the relative contribution of industry and the motor vehicle or activities of the general public to levels of air pollution, from estimates made it has been stated that, ". . . if the Sunday pollution levels were much lower than weekday levels, it might be reasoned that spectacular reduction of pollution by industry will reverse the present

2. Went, F. W. Global Aspects of Air Pollution as Checked by Damage to Vegetation. Proceedings, Third National Air Pollution Symposium, Pasadena, Calif., pp. 8–11, 1955.

trend toward dirtier air. If the difference between weekday and Sunday pollution is small, it may be reasoned that it is the public in all its activities that has to do the real cleanup. . . . Unfortunately, this latter seems to be the case. . . ."[3]

The principal source of motor vehicle emissions is the tailpipe exhaust. Pollutants result also, however, from the venting of vapors and fumes from the crankcase and from gas tank and carburetor evaporation. Solving the problem of motor vehicle pollution depends on control of all four sources. Primary emphasis in California's control program is now being given to the tailpipe exhaust and crankcase emissions since they constitute about ninety percent of the problem.

STANDARDS FOR AIR QUALITY AND MOTOR VEHICLE EMISSIONS

California took a significant step in the evolution of air-pollution control when it first established standards for air quality and motor vehicle emissions in 1959.[4] The ambient air standards together with the exhaust and crankcase emission standards will serve as guide lines for local control agencies who are responsible for controlling air pollution from stationary sources and for the state motor vehicle pollution control board that is responsible for controlling mobile sources of pollution from passenger cars, commercial vehicles, and trucks.

The air quality standards are designed to reflect the relationship between air pollution and health, including irritation to the senses, damage to vegetation, and interference with visibility. Motor vehicle emission standards are based on the ambient air standards and were determined by calculating the needed reduction in the average concentration of certain substances in motor vehicle exhausts to achieve the desired community air quality as defined by the ambient air standards.

Motor vehicle exhaust emission standards have been established for hydrocarbons because their reduction is necessary for limiting the creation of photochemical smog and for carbon monoxide be-

3. Stern, Arthur C. Changes in Identity and Quantity of Pollutants, Past, Present, and Future. Proceedings, National Conference on Air Pollution, U.S. Dept. of Health, Education & Welfare, Washington, D.C., p. 93, 1958.

4. State of California, Department of Public Health. California Standards for Ambient Air & Motor Vehicle Exhaust. Berkeley, December 1959.

cause of its adverse physiological effects. The present standards provide a sound basis for California to initiate its program to control motor-vehicle-created air pollution.

As additional data on other pollutants are developed which show them to be significant contaminants, it will be necessary to set standards for these specific pollutants. For example, it may well be that standards will be necessary for oxides of nitrogen, which also participate in creation of photochemical smog, and aldehydes which appear to be significant odor factors as well as participants in creation of community air pollution.

THE OCCURRENCE OF AIR POLLUTION

When the contaminants produced by the motor vehicle react in the air, they produce the manifestations of photochemical smog including reduction in visibility, eye irritation, respiratory distress, cracking of rubber tires, and damage to vegetation.

The intensity and magnitude of the smog problem in any area is a function of such factors as the nature of the area's industrial activities, population concentration, the effectiveness of local governmental activities in controlling stationary pollution sources, and of great importance, the terrain and weather conditions that may or may not provide ventilation necessary to remove pollutants from the area.

The damaging and irritating effects of smog, first reported from Los Angeles in 1944, have since been detected in twenty-six of California's fifty-eight counties, affecting a total area of 14,463 square miles.[5] Although it was once maintained that photochemical smog traceable to the motor vehicle was a problem peculiar to California because of its particular climatic and geographic conditions, there is now evidence that the automobile is a principal contributor to air pollution in other parts of the nation and the world.

Manifestations of photochemical air pollution have now been seen and reported in urban and their adjacent rural areas in 19 states (Arizona, California, Colorado, Connecticut, Delaware, Hawaii, Illinois, Indiana, Maryland, Massachusetts, Missouri,

5. Middleton, John T., J. B. Kendrick, Jr., and H. W. Schwalm. Injury to Herbaceous Plants by Smog or Air Pollution. U.S. Dept. Agric. Plant Disease Reptr. 34: 245–252, 1950.

North Carolina, New Jersey, New York, Ohio, Pennsylvania, Utah, Washington, and West Virginia); the District of Columbia; the Province of Ontario, Canada; and Baja California, Mexico.[6] They have also been reported in cities in other countries including London, Manchester, Paris, Cologne, Copenhagen, São Paulo, and Bogota.[7]

Another indication of the widespread effects of air pollution is damage to tobacco now known to be caused by traces of ozone that arise from the photochemical oxidation of hydrocarbons from motor vehicles in the presence of oxides of nitrogen. The damage to tobacco crops on the eastern seaboard of the United States amounted to $25 million in 1959. Multi-million dollar damage to tobacco crops has also occurred in the Province of Ontario, Canada, in recent years.

While the principal problem with photochemical smog is in urban areas where the intensity and frequency of air pollution attacks continue to increase, there has been increasing evidence of its intrusion in non-metropolitan areas. It has been shown that the effects of air pollution are transmitted in accordance with topography and wind patterns to areas some distance away from the initial pollution source.

PROVISIONS OF THE LAW

Manifestations of damage may vary too as the polluted air moves away from the originating source depending on such factors as the reaction rate of the contaminants and the type and amount of emissions added to it. The intrusion of air pollution into non-metropolitan areas has been seen in California. It has also been seen in other parts of the country. For example, damage to plants in the Delaware River valley is caused by air pollution originating in metropolitan Philadelphia, that in the Potomac River valley originating in Newark and metropolitan New York.

The new motor vehicle pollution control legislation[8] provides for a 13-member motor vehicle pollution control board (9 members appointed by the Governor and the directors of four state

6. Middleton, John T., and A. J. Haagen-Smit. The Occurrence, Distribution and Significance of Photochemical Air Pollution in the United States, Canada and Mexico. 53rd Annual Meeting, Air Pollution Control Assoc., Cincinnati, Ohio, May, 1960.

7. Went, F. W. *Op. cit.*

8. California Health and Safety Code, Division 20, Chapter 3.

departments), a system of adopting criteria for certifying control devices, and a time schedule for providing devices for all California motor vehicles. The board has been assigned the following specific duties:

1. To determine and publish the criteria for approval of motor vehicle pollution control devices. Determination of such criteria shall be based on a number of factors including the cost of the device and its installation, its durability, the ease and facility of determining whether the device, when installed on a motor vehicle, is properly functioning, and other factors which render a device suitable or unsuitable for the control of pollution or for the health, safety, and welfare of the public.

2. To issue certificates of approval for devices which are found by the Board to meet the standards established by the State Department of Public Health and criteria adopted by the Board.

3. To exempt from requirements of the law those classes of vehicles for which devices are not available and also those classes of vehicles which are designed to meet and operate within the standards without the addition of other equipment.

In addition, the Board is authorized to adopt rules and regulations that are necessary to execute its powers and duties, employ necessary staff, and contract for the use of laboratories, either public or private, to perform necessary testing of devices for purposes of certification.

Solution of the motor vehicle pollution problem depends on the control of total contaminant emissions including the tailpipe exhaust, crankcase emissions, gas tank and carburetor evaporation. The most important aspect of the board program is control over exhaust because it constitutes up to seventy-five percent of total vehicular emissions. Control of pollutants emitted from the crankcase which comprise a lesser proportion of the total is more easily achieved. The American automobile industry has voluntarily made devices to control these blowby emissions available on 1961 model cars offered for sale in California.

While the California Board has not made installation of such devices mandatory, it recognizes their value not only for California but for the nation. The Department of Public Health adopted standards for crankcase emissions in December, 1960.

The board, therefore, has begun to develop criteria and procedures for testing these crankcase emission blowby devices as a prerequisite to their approval and the establishment of a requirement that they be installed on vehicles in California.

The board is now proceeding with its program to see that control over the most significant source, the tailpipe exhaust, is achieved. Control devices will be required on all new motor vehicles within the state which emit more pollutants than the standards allow. The year this will occur depends upon the date the board certifies two or more devices. This date is defined as the certification date. The legislation states that devices will be required on these new vehicles as a requisite of registration ". . . after one year after the certification date." Within three years after that, all used vehicles will be required to have devices in those counties which do not exempt themselves from the program.

The legislation provides that counties which determine after public hearing that they have no air pollution problem, that air quality in the county meets the state air quality standards, may adopt a resolution exempting themselves. The counties that do exempt themselves must reassess their air pollution problem every two years.

THE CONTROL BOARD PROGRAM

For used vehicles in those counties that participate in the program, the legislation stipulates that ". . . no used motor vehicle upon transfer of registered ownership shall be registered one year after the certification date . . .", ". . . that no used commercial vehicle shall be registered after the second December 31 next following the certification date . . .", and ". . . that no vehicle shall be registered after the third December 31 next following the certification date. . . ."

Thus once this Board has certified devices, a preset schedule will go into effect which will determine when motor vehicles within those areas experiencing air pollution shall be equipped with control devices.

The board, since its appointment in July 1960, has been developing an action program that considers the development and specification of criteria, the procurement of laboratory facilities,

the employment of a technical staff, and the definition of testing procedures for evaluation of devices.[9]

Device approval and certification require that devices meet, in addition to the state standards for specific contaminant emissions, other criteria to be determined by the board. Because of the large number of automobiles affected and the tremendous expenditures which will be required of California's motoring public, the board is specially concerned that it certify only those devices that will protect the public interest.

Safeguards will be provided by the board's certification program and adoption of criteria which will assure that the devices operate safely, are not noisy, and do not adversely affect engine operation. The effective life and the cost of devices, including cost of installation, maintenance, operation and replacement are criteria of particular concern.

The Board will also consider life of the device from the standpoint of an inspection system. Because of the large number of devices that will be in use, it is probable that an inspection program designed to measure the effectiveness of an installed device on an operating vehicle would be prohibitively expensive and time consuming.

The board has adopted a policy of testing devices in steps, the first step being to determine if devices meet the state standards for hydrocarbon and carbon monoxide emissions. This first step test is but one in a series of tests leading to eventual device certification. Thus, rather than delaying the board program until the information necessary to establish additional criteria can be acquired, the board can proceed with an orderly development of its program, leading to early device certification.

Efforts are now being directed toward establishment of additional criteria which will assure certification of devices which will be in the best interests of the public. These additional criteria relate to such characteristics of the device as cost, life, safety, noise, excessive heat, effect on engine operation, and effectiveness of the device under abusive driving conditions.

With the aid of technical advisors from the automobile and chemical industries, engineering and research institutes, and related

9. State of California, Motor Vehicle Pollution Control Board, Report to Governor Edmund G. Brown and the Legislature, January 12, 1961.

professional societies, the technical staff is proceeding with the establishment of detailed testing procedures, appropriate methods of measurement, and reliable techniques for evaluation to insure that devices do comply with both the standards and other Board adopted criteria.

Applications have been circulated to about 100 firms and individuals who have indicated they wish to submit devices for testing leading to certification; the Board now has laboratory facilities under contract and will begin its testing as soon as devices are submitted to it. Should these devices meet both the State standards and Board criteria, it should be possible to certify the requisite number of acceptable devices in 1961.

SOME CONSEQUENCES OF THE PROGRAM

Even so, the control program for new motor vehicles cannot be operative prior to 1963, which illustrates the importance of rapid development by industry of devices that will reduce air pollution and meet Board criteria relating to protection of the interests of the motoring public.

The imperativeness of rapid initiation of the actual control program becomes even more apparent by looking at the estimated growth of California's motor vehicle population from today's eight million motor vehicles to eighteen million by 1980.

It is probable that more than one million vehicles will have to be equipped with devices within one year after devices are certified as a result of the law. The number, of course, will depend on the rate of increase in car sales in California. In 1959, 604,004 new passenger cars and 100,677 new commercial vehicles were sold and registered in the state, or a total of over 700,000.

These new vehicles comprised close to 10 percent of the state's total 1959 motor vehicle registrations. Assuming the proportion remains the same, it can be estimated that the number of new cars requiring devices each year will increase to about two million in 1980.

The number of devices that will be required for original installation on the other ninety percent of California's vehicles will depend on the decisions made by the counties as to whether or not they will participate in the control program.

The largest proportion of these motor vehicles will probably be

included in the program and thus required to have devices since about eighty percent of the state's automobiles are within counties that have already recognized air pollution as a problem through activation of air pollution control districts. Assuming that the control program is in effect for all used cars within these counties by 1965, about five million vehicles will have to be equipped.

The number of devices that will be required for replacement installation will, of course, be a function of the effective life of the devices certified by the board. Ideally, the devices should last the lifetime of the car. Practically, the board is planning to certify only those devices which have an effective life of at least one year based on state vehicle registration periods.

The number of devices that will be required will also depend on whether or not certain classifications of vehicles may be so designed and produced as to meet the standards without devices and so may be exempted by the Board from compliance with installation requirements.

PROSPECTS FOR AIR RESOURCE CONSERVATION

In California, the need for control of motor-vehicle-created air pollution is well established. Future population growth and industrial development will largely be determined by California's ability to control air pollution.

Air pollution, its effects, its causes, and the part played by the motor vehicle is of increasing concern to urbanized areas throughout the United States. The outcome of California's program will be watched closely by the rest of the nation and will serve as a guide for other governmental control activities.

While it is vital that motor vehicle emissions be controlled to preserve air as a vital natural resource, its control cannot be considered the complete solution to the urban air pollution problem. The continuing role and importance of stationary industrial and domestic combustion sources in urban air pollution and their relation to mobile sources has recently been described by Professor A. J. Haagen-Smit.[10]

The need for continued control of stationary sources in addition to the necessary control over mobile sources was pointed out by the

10. Haagen-Smit, A. J. Urban Air Pollution. Advances in Geophysics 6: 1–18, 1959.

assembly interim committee on public health in 1960 when it stated that, "This committee wishes to emphasize again the need for increased and strengthened control throughout the state over local stationary sources of air pollution by the local counties and air pollution control districts.

"The preservation of California's air resource can be achieved only with effective local control in conjunction with an effective state program of control over motor-vehicle-created air pollution."[11]

The air pollution problem cannot be considered except in relation to other community problems accompanying rapid metropolitan area growth. The conservation of air as a resource is related to the problems of and need for total community planning for such things as industrial and residential zoning, freeway location, and rapid transit development. The Governor's Commission on Metropolitan Area Problems in discussing this said, "Ultimately more far-reaching measures may be necessary as the concentrations of people and cars in our metropolitan areas increase.

"Some members, for example, believe it may become necessary to encourage or even require the use of motor vehicles not powered by internal combustion engines; automobiles powered by other fuels or by batteries or fuel cells may have to become a reality. Discouragement of expanded use of private automobiles by limiting freeway expansion and favoring rail rapid transit may also, through a developing emergency, become unavoidable."[12]

The success of the motor vehicle pollution control board program is dependent on the co-operation of industry which must develop, manufacture and distribute devices at an early date. It further depends on the co-operation of the public whose motor vehicles will have to be equipped with devices.

It is exigent that the public recognize the need for control of motor vehicle pollution. It is vital that the public recognize that air is no longer a resource to be taken for granted and neglected. And it is essential that the public know that the benefits of control, though not immediately apparent, far outweigh its cost and inconvenience.

11. Assembly Interim Committee Report to California Legislature, 1959–1961, Subcommittee on Air Pollution. Volume 9, Number 22, December 1960.

12. Governor's Commission on Metropolitan Area Problems, Special Report to Governor Brown. January, 1960.

Scare Technique and Traffic Safety

JAMES L. MALFETTI

Dr. Malfetti is Associate Professor of Education, and Executive Officer of the Safety Research and Education Project of Teacher's College, Columbia University. He is the author of "Electronic Techniques for Traffic Control and Safety," STATE GOVERNMENT, November, 1958; "Traffic Safety, the Driver and Electronics," TEACHERS COLLEGE RECORD, November, 1959, and "Traffic Safety and the Adolescent Driver," JOURNAL OF SCHOOL HEALTH, June, 1960, etc. He is a member of the American Psychological Association, and of the American Public Health Association.

IN traffic safety compaigns, scare techniques are common. So are claims for their effectiveness. But there is no evidence for these claims. In fact, psychological studies in related fields show that scare campaigns as now conceived may do more harm than good.

Recently, two hundred traffic safety authorities throughout the United States were asked to send to the author of this article information on scare techniques in their communities. Scare techniques were defined as those meant to raise a high degree of fear in an effort to improve driving behavior.

PREVALENCE OF SCARE TECHNIQUES

The response was overwhelming. Some of the horror-and-anxiety-provoking material received was produced for profit. Most of it however was developed and distributed by officials and laymen intent on doing good.

One distributor[1] sold since 1953 two million copies of a booklet, "Death on the Highway," and 2,000 copies of color movies and strip films with the same title. More than 800 high schools have the films in their libraries. More than 2,000 corporations regularly show them to employees before vacations and holidays. How gruesome is "Death on the Highway"? An excerpt from the advertising reads:

"This new film shows decapitations, multiple compound fractures, intestines strewn over the road, flesh burned from bones, and arms and legs

1. The Suicide Club, Box 2704, Fort Myers Beach, Florida.

torn from the human body. Not a pretty picture—but the horrible impact will bring home to the most complacent, the greatest danger of modern living, DEATH BY AUTOMOBILE. . . . This is such a dramatic and graphic movie that seeing it will make a more careful driver out of you, or you will give up driving altogether."

Other exhibits collected across the nation include pictures of naked, mutilated corpses of children killed in traffic accidents, billboard displays asking, "Are you next?," and death at intersections saying, "I wait for those who don't slow down."

At this writing, a naval air command is displaying pictures of wrecked cars in which base personnel were killed; highway signs warning that "Traffic laws are enforced with planes, radar, unmarked cars," and "Speed kills." Wrecked cars, dummy corpses and caskets are mute testimony at intersections, and white crosses are planted on highway death spots.

At least five films and ten booklets like "Death on the Highway" have been produced and vigorously circulated by state police departments, medical associations, motor vehicle departments and newspapers.[2] Insurance companies are using pictures of serious wrecks in their advertising.

The walls of a state licensing agency are papered with large revolting photographs of fatal accidents. And "The life you save may be your own," and lugubrious holiday week-end forecasts are the messages for which our major national traffic safety organization is well known.

Fear-provoking posters dominated a recent international road safety exhibit.[3] Scare techniques are worldwide.

WHY SCARE TECHNIQUES?

Why do scare techniques prevail? For one reason, some officials and civic groups think that the best way to get people to do anything is to scare them into it. For another, some of the best known experiments on motivation compare emotion and reason: investigators have reported that communications with emotional appeals were more effective than those relying exclusively on the rational.

2. Outstanding is "Battle of the Roads" by the *Daily Mirror*, of London.

3. "International Exhibition of Road Safety Posters," *International Road Safety and Traffic Review*, Spring, 1959, pp. 31–37.

Here, it seems some scare enthusiasts get scientifically encouraged.

One classic experiment[4] investigated the effects of two different types of political propaganda, using election returns as a behavioral index of communication effectiveness. The emotional appeal got more votes. But this experiment ran the full gamut of emotions, positive included. Our concern is with techniques accenting fear alone.

It should, however, be admitted at the outset that a scare technique sometimes seems capable of motivating group action for improvement. In this respect its face value was demonstrated spectacularly in August, 1935, when an article entitled "...And Sudden Death," by J. C. Furnas appeared in Reader's Digest. It described with sensational realism the results of traffic accidents—skulls crushed, bodies torn apart:

"... Like the gruesome spectacle of a bad automobile accident itself, the realistic details of this article will nauseate some readers. Those who find themselves thus affected at the outset are cautioned against reading the article in its entirety, since there is no letdown in the author's outspoken treatment of sickening facts.

"... But what is needed is a vivid and sustained realization that every time you step on the throttle, death gets in beside you, hopefully waiting for his chance.

"... The driver is death's favorite target. If the steering wheel holds together it ruptures his liver or spleen so he bleeds to death internally."

In short the article was so shocking it was fascinating. Millions of reprints were distributed by civic agencies. (Its popularity is further attested to by the fact that two copies of *Reader's Digest* in which it appeared are preserved in the Columbia University Library, but the article has been removed from both.) The problem of controlling traffic to avoid this carnage became almost overnight the subject of conversation by people of all kinds everywhere.

The Furnas piece sparked an explosion of public interest in traffic safety.

"It created quickly a climate of opinion favorable to recruitment and training of traffic police, development of traffic engineering techniques, improvement of obsolete and hazardous highways, driver education in

4. George W. Hartmann, "A Field Experiment on the Comparative Effectiveness of 'Emotional' and 'Rational' Political Leaflets in Determining Election Results," *Journal of Abnormal and Social Psychology*, 1936, 31: p. 99–114.

public schools, and other activities which have come to be recognized as essentials of successful safety programs."[5]

Why then do we claim scare techniques are ineffective? There is certainly no shortage of other examples in which publicized highway slaughter moved communities to set up preventive machinery. We believe they are unproductive for two reasons: (1) they are repeatedly relied on by some groups to stir up and maintain public interest, and (2) the impression exists that because they sometimes muster civic groups to action they will improve the behavior of individual drivers. In plain fact, these are two unfortunate misconceptions.

HOW EFFECTIVE ARE SCARE TECHNIQUES?

For Civic Groups: The first misconception—that scare techniques are repeatedly effective in rousing and holding public interest—can be attacked pragmatically.

There has never been another "... And Sudden Death" though Furnas and many others have tried. In the hope of combatting a rising traffic fatality rate in 1944, "... And Sudden Death" was republished in the December 1945 *Reader's Digest.* What happened? Largely a loud silence, and a singular lack of action. It drew a blank.

Most long-time safety professionals can name a scare technique that launched a commendable traffic campaign. It was like a first draft of strong medicine. But they can also point to failure of succeeding doses. They feel the explanation is obvious: repetition breeds immunity. Inoculated continuously, people become indifferent and even unwilling, particularly because the serum is unpleasant.

Whatever the reasons, history reveals that communities that put on successful scare campaigns once, did not succeed again. I have been unable to uncover a single example of enduring results from continuous use of scare techniques.

They may also do more harm than good. Gibbons[6] expresses the view of a large number of safety professionals when he concludes that over-emphasis on scare techniques has at least two liabilities:

1. It is a waste of money, time, effort.

5. John W. Gibbons, "The Value of Shock Propaganda," International Road Safety Congress, September, 1958.

6. *Ibid.*

2. It draws attention from the real issue. Campaigns rooted in fear give organizations and civic leaders an outlet for their interest in traffic. After participating, they feel that they have played their part. They won't take a role in a meaningful sequel.

For individuals: Perhaps the greatest danger lies in the theory that because they sometimes favorably motivate civic groups, scare techniques will improve the behavior of individual drivers. Several factors militate against this erroneous conclusion.

AVOIDANCE BEHAVIOR

It is usually easier to induce someone to recognize the desirability of behavior change in others than to see it in himself. Driving is no exception. Surveys have established that most drivers—the majority—consider themselves superior. The wrecked cars and broken bodies incorporated in some scare programs go against this image of self esteem. Good Driver Me! The admonition "Don't let this happen to you!" is for someone else.

In all fairness to the driver, it seems to me that scare techniques have overworked the image of the homicidal maniac, an image with which the average driver will not identify. We know this but have tended to conclude that the self-image is wrong, that the driver deceives himself, and that he must be forced to admit his guilt.

Even if we succeed in convincing him, we have not produced a satisfactory attitude. Guilt does not usually lead to constructive self-discipline. It leads to resentment of critics, avoidance of the guilt-producing situation, or submissive conformity. Perhaps it is time we worked on the assumption which the facts prove—that the accident potential is, like ourselves, a fairly responsible, well intentioned human being.

This sense of personal invulnerability is more common than is generally believed. Prisoners in Nazi concentration camps who saw their fellow prisoners systematically killed each day persuaded themselves that they above all would be spared.

Many simply disbelieved in the possibility of their own death. Not believing, they did nothing to prepare for it. They made no plans for defending their lives if and when death were to become inescapable. Some, in fact, even though they could see the gas chambers and knew their function, denied their existence.[7]

Certainly a sense of personal invulnerability is easier to understand in a framework of traffic safety. One minimizes a threat if it is improbable or temporarily remote. And while expectations of personal exemption are frequently based on unrealistic rationalizations, in an automobile they can be empirically sound.

Every traffic fatality is a regrettable tragedy. Yet these account for only two to three percent of the deaths in the United States each day. The daily traffic death-rate is about twenty-five a year per 100,000 of population. One fatality occurs for each 16,000,000 miles driven. The driver has no good reason for preoccupation with a fatal accident. How can he associate himself with "speed kills" when such odds are riding with him.

Furthermore, an overwhelmingly large number of fatal accidents are *first* accidents. Of 294 Connecticut drivers in fatal accidents, eighty percent had never before been in a collision and sixty-eight percent had no history of violations or collision. There is inadequate psychological preparation for identifying oneself with gruesome accidents—and no psychological vaccine.

This concept of personal invulnerability is receiving practical recognition. Searching for a new deterrent—which may or may not work, Connecticut began in 1956 to suspend licenses on first conviction for speeding and other offenses. The proposition was that a driver who will not slow down to save his life, will slow down to save his license.

One organization recommended that since drivers believe that death is not the worst thing that could happen, emphasis in safety campaigns might be placed on fear of long-lasting pain, or permanent injury to the driver and his family.[8] Others have suggested arousing the important images of the family and relating personal careless driving behavior to these.

Such ideas have been incorporated into several programs. In one case, newspaper advertising mats[9] illustrated some appropriate captions: "This child is scheduled to be an orphan tomorrow,"

7. Bruno Bettleheim, "The Ignored Lesson of Anne Frank," *Harper's* 221: 45–50, November, 1960.

8. Opinion Research Corporation, *What Motorists Really Think About Traffic Safety*, American Trucking Association Foundation, Washington, D.C., 1958.

9. These mats were widely distributed to advertising managers as part of a joint safety campaign of the Advertising Council and the National Safety Council in 1956.

"How does it feel to plan for a coffin?" (a picture of a mother and father presumably planning for the coffin of a child). "Forty Thousand Funerals" (a display of a woman weeping at a funeral). "Will your wife be a widow this year?"

In spite of the good intentions of sponsoring groups, such programs had little chance for success. Even if emotions were suitably aroused, the ways for capitalizing on them were not clear, and it is probable that nothing was done. This is a case of failure to channel the emotion aroused into the acquisition of safe driving habits.

In this connection the laboratory lesson on animal avoidance-learning is helpful. It demonstrates the acquisition of a new response through fear arousal.[10]

Typically, a noxious *unconditioned* stimulus such as electric shock is given to an animal several times, preceded by a neutral *conditioned* stimulus such as light. The animal, say a rat, responds to the shock with pain and fear. After sufficient combinations of the light-shock stimuli, he will react with fear to the light alone.

This fear is called *conditioned emotional response*. Once established, it can serve as a motivation for learning new behavior. But the rat has to find out what to do about the fear, how to get it turned off, how to escape from it; otherwise he hasn't learned.[11]

Applying this paradigm to the teaching of new responses to automobile driving, we can find similarities. The scare propaganda is intended to symbolize a situation which in reality produces strong pain and fear—namely, an automobile accident. If the real accident is an *unconditioned* stimulus, like the electric shock to the rat, then the scare devices, like the light, represent *conditioned* stimuli to arouse response to the real accident. Once this pain-fear response is elicited, the subject will seek behavior which reduces its intensity.

If the safe driving behavior recommended in the scare propaganda does not reduce fear at this point, the person tends to do whatever helped in the past. A frequent response would probably be simple avoidance of the fear-arousing stimulus. He might leave the frightening film, avoid the safety lecture, pay no attention to the poster, reject the recommended action, minimize the threat, or at the extreme, stop driving.

10. N. E. Miller, "Learnable Drives and Rewards," in S. S. Stevens, Editor, *Handbook of Experimental Psychology*, New York: John Wiley, 1951, p. 435–472.

What is needed is a recommendation the subject can act upon easily while experiencing the fear. Such a recommendation would have to be clear and simple. Vague admonitions to "drive safely" are probably worthless.

In view of the way this type of avoidance behavior operates, a look at current scare techniques is interesting. Almost without exception, specific recommendations are either vague or missing entirely. Consequently, the driver does not know how to turn off the fear or escape from it. Consequently he does not learn.

HOW MUCH FEAR IS DESIRABLE?

Before people can be influenced by outsiders, they must perceive the stimulus situation that is supposed to affect them. A situation first has to stand out from the complicated background which constitutes the normal environment. Furthermore, most persons dislike indoctrination or would rather not know it is being worked on them. Thus, whoever wishes to change behavior has to overcome this resistance and has to make his stimulus as compelling as possible. And scare techniques do seem compelling—at least to those who use them.

That is one reason why they are so often used. Another reason is that traffic accidents are "naturals." Broken bones, spattered blood, wrecked cars are everywhere. Of all the humanitarian causes, traffic safety lends itself best to the scare technique because of the repulsive character of accidents. But with all these raw materials for "scare" available, how much of them should we use? How much fear is desirable in getting people to change their behavior?

A classic study[12] in dental hygiene may give some clues. A fifteen-minute illustrated lecture was prepared in three forms. Each contained the same information about tooth decay and the same series of recommendations on oral hygiene. They differed only in the amount of threat material. The strong appeal emphasized painful consequences of tooth decay, like diseased gums, blindness and paralysis. The moderate appeal put the same thing in milder words, and the minimal appeal rarely alluded to it.

11. O. Hobart Mowrer, *Learning Theory and Behavior*, New York: John Wiley, 1960, p. 37.

12. I. L. Janis and S. Feshback, "Effects of Fear-Arousing Communications," *Journal of Abnormal Psychology*, 1953: 48, 78–92.

The strong appeal included many personal references; the moderate and minimal used impersonal language. The three forms were meant to stimulate emotional reactions and thus motivate the audience to conform to recommendations.

The forms were given to four groups of fifty high school students —three experimental (strong, moderate, and minimal appeal) and one control. A questionnaire on dental hygiene practices was administered to all just before the lectures and again one week later. The experimental groups were also tested on the information given in the lecture. The results indicated that:

1. There were no group differences in information test scores. All learned the recommended dental practices equally well.

2. The strong-appeal group showed least conformity and the minimal appeal group showed the greatest to the practices recommended. In fact, the strong fear appeal produced no significant change in reported dental behavior. Apparently, as the amount of fear arousing material is increased, conformity to recommendations tends to decrease.

3. A week after the lectures, when given a statement counter to the lecture recommendations, the minimal-appeal group was least influenced, and the strong group most influenced. Subsequent exposures to counter propaganda do in effect indicate strength or stability of attitude built by the original communication.

The results suggest that under exposure to communications competing on the same issues, the strong-threat appeal will produce fewer stable and persistent attitude changes than the minimal. Thus, in both short- and long-term results, the minimal fear group was most responsive.

STRONG FEAR APPEALS

Other findings of the same study revealed that those exposed to strong fear worried most, and that the moderate group worried more than the minimal. The more vividly the unpleasant aspects of a potential threat are described, the more emotional tension is evoked.

The question has been raised of whether strong-fear appeals are equally effective for all mental types of drivers. Is there a danger of creating a fear psychosis of accident inevitability in certain drivers?

One authority[13] raising the question cited a case where a couple of highly publicized serious accidents, one after the other on the German Autobahn, had been given as the reason for an accident occurring a week later at the same spot. The driver said he was psychologically affected by the publicity on the previous accidents.

Another investigator's remarks are similar:

> If fear has, as I have suggested, some restraining value for the small minority, the cruel and callous, it is certainly very harmful at the opposite extreme, for the far larger number of the timid, anxious and "nervous" members of our community. The mere fear of the consequences of dangerous behavior may irresistibly impel those people to such behavior. There are many industrial workers who are more or less subconsciously afraid of the machines at which they daily work. This is likewise the case in certain car drivers. In them (and also in others) gruesome propaganda will only increase (or arouse) fear in a situation of danger and will thus only increase the rush of accidents. I know of a motorist who once saw a horrible accident on a piece of road well known to her. She assured me that the result has been that when she passes this spot she always drives badly and dangerously, through the sheer panic of impending disaster.[14]

Authorities at a recent symposium on shock propaganda[15] drew a comparison between the effects of public health propaganda on cancer, heart disease, etc., and those of traffic scare propaganda. They claimed that both induced an anxiety complex and that persons with traffic anxiety might be frightened into further accidents. This was particularly so if the scare technique was not immediately supplemented by positive advice on avoiding road accidents.

Those who might be afflicted with traffic anxiety should not be left in a void. They should be given specific instruction immediately. To avoid extreme reactions of anticipating anxiety in such people, it is wise to bring about awareness of the threat step by step. In the person's image of his own future, the threat must come gradually into focus until it ceases to be overwhelming.

This orderly increase in awareness may stimulate him to imagine

13. "The Value of Shock Propaganda," *International Road Safety and Traffic Review*' Spring 1959, p. 30.

14. Charles S. Myers, "The Use of Gruesome and Humorous Propaganda for Accident Prevention," Human Factor (*Occupational Psychology*), Volume 10, Nos. 7–8, 1936, p. 267–272.

15. See footnote 13.

the future danger and lead to a variety of personal means for conquering it. Such internal preparation probably leaves the person psychologically less vulnerable when confronted with subsequent anxiety arousing events. Unfortunately, shock and surprises are elements in scare techniques, so that step-by-step preparedness cannot be achieved.

Apropos of this, investigators[16] have found that high muscular tension accompanies anxiety. Even more typical, however, is a spread of this tension, which can destroy every organized pattern of motor response. Perception is decreased, ability to perceive meaningful sentences is lowered, words representing some personal threat tend to be perceived more slowly, and attention and concentration to be adversely affected.

What is suggested here is that *scare techniques may influence different drivers in radically different ways, some of which may encourage the very accidents they try to prevent.* And there is at present no way of knowing how many drivers are being influenced in what ways.

Strong-fear methods raise other dangers. One study[17] revealed that while a scare appeal did not interfere with the learning of basic facts, it did help select what was retained. The strong-fear appeal group paid attention to the gory depictions, which could be detrimental in attempting to cope with danger later on when knowledge of causes is important.

In traffic scare appeals, the audience may remember the tragedies but not what *caused* them. Since the recommended behavior is presumably based on correct understanding of causes, this might lead to inefficient coping with traffic dangers. If attention is directed to suffering and death, the more factual information about causes and prevention may be overlooked.

The author was present about two years ago at a showing of gory slides of accidents that could have been less injurious if seat belts had been worn. The purpose of the meeting was to encourage the use of seat belts. Since then I have talked with about twenty people who were there. Without exception we covered extensively

16. Paul H. Hoch and Joseph Zubin, Editors, *Anxiety*, New York: Grune and Stratton, 1949.

17. I. L. Janis and H. C. Milholland, "The Influence of Threat Appeals on Selective Learning of the Content of a Persuasive Communication," *Journal of Psychology*, 1954, 37, pp. 75–80.

the gory nature of the slides. But there was no mention of seat belts. We remembered the effects of the poison but forgot an antidote.

May I repeat that most of the materials I collected and described earlier in this paper I judge to be in the strong fear appeal class. In view of the possible dangers peculiar to strong fear appeals, it is disheartening to know they are so common.

SOURCE OF THE COMMUNICATION

The effectiveness of the scare technique may also depend in part on who fashions it. Whenever a communication contains potential threats, its impact has something to do with appraisals of the communicator.[18] If he is uninformed, his predictions may be discounted. If he seems to be trying to manipulate emotions, he may get nowhere. The audience may react to an exaggerated threat by concluding the communicator is "trying to scare us to death" and to disregard him as an extremist.

And since arousal and alleviation of emotional tension are part of scare techniques, there is always the possibility of audience aggression, or other unintended effects. Experiments confirm the hypothesis that when a communicator arouses resentment by making statements regarded as offensive, the audience is also poorly disposed toward what he is trying to do.

If he arouses anxiety unreduced by reassurances in either his material or his manner, the emotional hangover may spoil his chances to develop new habits. The individual may ward off subsequent exposures to the "scary stuff," and try to avoid thinking or hearing about it ever again. Net result: loss of interest.

In short, when scare techniques are used, it must be recognized that the hoped for effects may not only not be achieved, but that the entire effort might boomerang.

SUMMARY AND RECOMMENDATIONS

Scare techniques intended to raise a high degree of fear to improve driving are common. They are practiced primarily by officials and citizen groups sincerely devoted to reducing highway tragedies.

Informed opinion of traffic safety specialists and the findings of

18. Janis and Feshback, *op. cit.*

experimental psychological studies in related fields suggest that while these techniques are sometimes effective in creating public interest in safety, they are, as presently conceived, ineffective in improving the behavior of individual drivers. In fact, they may do more harm than good.

To be effective a "threat" appeal should:

1. Raise a minimal amount of fear (or just the right level of it, as interpretations differ with people).

2. Capitalize on the fear by suggesting specific actions to reduce it.

Ironically, most scare techniques in traffic safety attempt to raise a high level of fear and are accompanied by vague and sometimes complex messages.

As presently conceived, the programs run the risk of creating an unresolved high level of anxiety in some persons and therefore make them less capable drivers, of diverting the energies of the organizations sponsoring them from more meaningful activities, and of creating an unfavorable public climate for traffic safety programs.

In spite of large human and financial resources evidently devoted to scare techniques in traffic safety, no experimental studies have been made to provide a rationale for their use, or to evaluate them. In such a vast and important area of social concern we seem to be content to walk in the dark.

I recommend immediate experimental studies of scare techniques in traffic safety, so that if they have value the conditions for exploiting it are made clear; and if they do not have value, that we abandon them for more meaningful pursuits. I further suggest experimental studies in the use of positive emotional appeal as an influence on driving behavior.

My research for this paper convinces me that specialists in the human sciences have devoted extraordinarily little attention to the motivational aspects of pleasant emotions, and no attention at all to the relation of these to driving.

Traffic Assignment by IBM

GERALD WOOD

Mr. Wood is a member of the Urban Traffic Section, Division of Highway Planning, Missouri State Highway Department. He was the project engineer for the Highway Department in the Kansas City Metropolitan Area Traffic Survey.

IN 1957, the Missouri State Highway Department started traffic surveys in the state's two largest metropolitan areas, St. Louis and Kansas City. A traffic engineering consultant was retained to direct the collection and analysis of data. The results of these surveys were submitted to the Highway Department in November, 1959.

It became apparent, after publication of these reports, that many problems needed further study. The division of highway planning received requests for additional information not contained in the report. We had no established method to determine this information.

One of the problems was incomplete information for traffic assignment on city arterial streets. We lacked the arterial street volumes. These volumes would benefit us in three ways. They would provide design-information for structures carrying the arterial street traffic above or below the freeway, point out and help to relieve overloading conditions on arterial streets, and help to resolve differences of opinion on the volume-ratio between city arterial streets and freeways.

It was believed that if a method of continuing analysis of the basic system could be implemented, it would provide the desired volumes and furnish additional information of value. We turned to the bureau of public roads in search of the tools necessary to adequately revise the system. The bureau provided a computer program, it had developed, that assigned traffic to an arterial street network as well as to a freeway network. The program is outlined in Highway Research Bulletin 224, "Program for Assigning Traffic to a Highway Network," by Glenn E. Brokke.

At this time, the forces of our own computer section were brought into the picture. We asked them to evaluate the bureau's traffic

assignment program. They said they could develop a computer program for use on our IBM 650 computer. The bureau reported that other organizations, attempting to develop this type of program, were limited by computer capacity. As far as we knew there had not been a 650 computer program developed to handle cities as large as St. Louis and Kansas City. Our computer section was confident it could overcome the capacity problem if given a chance to explore and develop its ideas.

At this point, we needed to compare the two alternatives to the problem. We selected the following items as the main points to be considered:

1. The bureau of public road's program was already written and field tested. We would need to develop and write our own.

2. The bureau program was for a large computer—IBM 704. There were only a limited number in the country. Locating these computers would necessitate traveling, and hiring an operator. If a program for the *650 computer* could be developed, we would have the computer in our own building with an experienced operator available.

3. Scheduling was another problem. The bureau of public roads had been using the bureau of standard's 704 computer in Washington, D.C. Computer-time available to run traffic assignments was limited to week-ends and the schedule was tight. Our 650 computer was available, since it was operated only ninety percent of the time.

PROGRAM WRITING AND TESTING

Comparative computer running time, final product costs and size of program were factors that became important as the program developed. At this stage of development, we lacked sufficient information to evaluate the factors accurately.

These three considerations indicated we should develop a program for the 650 computer. We decided to adapt the bureau of public road's 704 program to our computer. We would use the same minimum time path concept to build trees. The accumulation of traffic volumes would be essentially the same as the 704 program. With this program as a guide, our computer section proceeded to develop a program for the 650.

In writing a program, a definition of the terms used is necessary. Below is a list of terms used in the 650 program.

Nodes: A node is any point needed for identification purposes. Nodes are used to designate zone centroids, highway intersections and external stations.

Links: A link is the connection between two node points. Links are used to connect sections of a road network.

Strings: Strings are made from a series of links and represent individual streets within the road network.

Tree: A tree consists of minimum path routes from one node to all other nodes in a road network. Trees are usually built from the zone centroid node.

Barrier: The barrier is comprised of a string or series of strings extending from one side of the survey area to the other and dividing the area in half as nearly as possible. The function of the barrier is to allow the program to be run in parts and to tie the parts together.

To overcome the capacity limitations of the 650, our computer section proposed to divide the area with a barrier, work each part separately and then combine the parts. This idea will hereafter be referred to as the barrier method. Many schemes to develop this method were tried before we obtained a final workable solution.

Careful selection of the barrier is necessary for successful operation of the barrier method. The routing between zone pairs on opposite sides of the barrier can cross the barrier only once. This necessitates the use of a string or series of strings extending from one side of the study area to the opposite side.

To obtain maximum use of the computer's limited capacity, the node points on each side of the barrier must be divided equally insofar as possible. To prevent multiple crossings of the barrier, a relative high speed facility is recommended for the barrier. This reduces the possibility of crossing the barrier to travel a paralleling route that is faster than the barrier.

Our program differs from the Bureau of Public Road's program in several ways.

One difference is the method used to number the node points. We use a four digit number selected at random, whereas in the bureau's program, it is necessary to number nodes consecutively according to type. It is not necessary to arrange our nodes in any

particular sequence within arterial or freeway groupings. We do not assign a turn penalty by a positive or negative sign or a flag to reverse signs. This affords an easier method of coding the input data.

The first step in an assignment program is to select and test a barrier. Along with the previously described barrier location requirements are other program limitations. One of these limitations is that no more than 791 link node points and 200 zone centroid node points can be on one side of the barrier. Another rule limits the barrier to a maximum of 70 barrier nodes. This sometimes presents a problem—to divide the area into parts and still abide by all of the rules.

After the barrier is determined, test trees are built from zone centroids on both sides of the barrier to the barrier. The two parts are then joined to form a complete tree for each test zone. The minimum paths for each side of the barrier are tested for the entire routing to determine if there is one, and only one, minimum path for each specific zone pair.

If more than one path for zone pairs on opposite sides of the barrier is found, this indicates a hole in the barrier. A review and adjustment to the barrier is necessary before proceeding with the assignment.

During our program writing and testing phase, we experimented with an idea to provide not only the minimum path between zone pairs but also to determine an alternate path. While we believed that the minimum path principle was good, we believed our program would be better if more than one path could be developed. Several tests were conducted on alternate paths produced by increasing the turn penalty factor. Test trees for these alternates were built for a few selected zone pairs. A comparison of routings showed a very definite alternate path could be obtained with a moderate time increase in the turn penalty.

Another problem, and possibly the largest, was the amount of computer-time required to trace these alternate paths. The alternate path principle was discontinued mainly because of the excessive time required on the 650 computer.

Another phase of program testing involves calibrating the system. This is a method whereby the actual ground counts are

compared to traffic volumes from the assignments. These comparisons are limited to the arterial streets having traffic count information available. In both cities, a large number of ground counts were available to make this comparison. The results of this test pointed out the deficiency in the mechanical traffic assignment program. By making adjustments to the mechanical program, a better similation of traffic movement was obtained.

We found during the calibration tests that a large number of streets concentrated in one corridor would present problems. The street or streets with the higher speeds attracted almost all the traffic volumes and the remaining streets had little or no volumes. An adjustment of speed differential was necessary to distribute paths over all streets. The first attempt ot overcome this problem was to make spot manual adjustments to certain streets. This method did not prove entirely satisfactory, for it might improve conditions in one place but make them worse in others.

In our next attempt to calibrate the system, we developed a feature we call the speed flattener curve. This was a mechanical device whereby the extreme speeds were adjusted toward a middle average, therefore reducing the range of speed differential. The average street speed was determined to be twenty-three miles an hour. All streets having a speed above twenty-three miles an hour were reduced in speed. Likewise, all streets below twenty-three miles an hour were increased in speed. This mechanical adjustment was applied internally within the computer. It reduced the tendency for discrepancies to appear in other areas while improving the critical areas.

The speed flattener curve was developed for Kansas City where the street system is a grid network. The St. Louis street system is quite different, being of a radial and circumferential nature. When this mechanical adjustment was applied to the St. Louis street network, the same desirable results noted in Kansas City were not obtained.

Many of the trips in St. Louis are not driven in the most direct manner. Many trips go out of direction before arriving at a final destination. The use of the speed flattener curve suppresses this type of movement and does not always give desired results in systems similar to St. Louis.

Another phase of program testing is comparing the all-or-nothing method of assignment to the diversion curve method. By use of the all-or-nothing method, very heavy traffic volumes were found on the freeway system.

Our diversion curve method gave us, we believed, a more reasonable distribution of traffic between the freeway system and the city street system. Use of the diversion curve method almost doubled the computer time, but we thought the answers justified the added expense.

Our diversion curve was basically the AASHO curve but with one exception. We used only the top half of the curve, thus eliminating the diversion of trips to the freeway that have a time ratio of more than one. This elimination was for two reasons.

First, most of the freeway sections were loaded beyond capacity and we believed these trips would be eliminated from the freeway.

Second, and probably most important, was reduction of computer time for building freeway trees.

In the bureau of public road's program, it is necessary to increase the freeway speeds to trace a path for trips having a time ratio greater than one. The speeds then are reduced to normal once the path is determined. The bureau method produces some very erratic paths if the freeway speeds are increased very much. This would affect not only the tree paths of those trips with a time ratio over one, but would also induce error in tree paths with a time ratio under one.

A check of St. Louis survey data compiled by the consultant revealed that of the total traffic volume assigned to the freeway system, only 6.8 percent of the volume had a time ratio of one or greater. The consultant had used the BPR assignment curve, which assigns a lower percentage of trips to the freeway than does the AASHO curve. At a time-ratio of one, the BPR curve assigns forty percent of the traffic to the freeway system while the AASHO curve assigns 48 percent.

We apparently were losing 6.8 percent of the freeway volume by not using the lower part of the BPR curve, but we believed we were more than compensating for this loss by using the AASHO curve.

As this writing and testing progressed, we gained confidence. We knew this program could be developed for use on a small

computer. Our computer staff had developed their ideas into a program that would give the desired assignments.

One difficulty encountered was the length of time required to complete an assignment. Using the diversion curve method of assignment, about 190 to 215 hours of computer-time is required to complete an assignment for either Kansas City or St. Louis. Both cities have about 1,300 link node points and 270 zone centroid nodes.

The following table shows the amount of time required for each phase of the assignment program:

	hours
Prepare input data	3—4
Build arterial tree system	46—48
Build freeway tree system	46—48
Accumulate arterial volumes for 100 to 130 selected nodes (540 movements)	10—12
Accumulate freeway volumes for 100 to 130 selected nodes (540 movements)	10—12
Accumulate freeway and arterial volumes on the barrier (40–60 nodes)	16—18
Total	131—142

The accumulated volumes of 100 to 130 selected node points, as mentioned, were not sufficient to study the entire area adequately. At least 400 to 500 node points, involving sixty to seventy-two additional hours of computer running time, were necessary to arrive at a minimum practical review of the network.

Many factors were involved in figuring computer-running time. One factor to consider was the method of assignment. The all-or-nothing method required about one-half the computer running time required by the diversion curve method. The lesser time was a result of tracing only one minimum path and accumulating volumes for this path. The diversion curve method called for two paths and and accumulation for each path.

Another factor was the actual number of zones having trip exchanges between them. Obviously, the smaller the number of exchanges the less computer time involved to accumulate these volumes.

Still another factor to consider was the number of arterial nodes an individual would select to present the complete picture. The complete turning volume on each arterial node requires both freeway and arterial accumulations. By obtaining turning movements for only the freeways, the computer time for accumulations was reduced considerably.

The computer running times listed above are averages derived from our work with the assignments in Kansas City and St. Louis. We used the diversion curve method and accumulated on about 190 freeway nodes, forty-five barrier points and 300 arterial points. This number of points gave a fairly complete picture of traffic volumes on all of the freeways and major arterial streets. It also supplied us with turning movements for these facilities.

The process of tree building consumed the same amount of time for each new assignment caused by a change in the system. Once the trees were built, the length of time required to obtain the desired volume information could vary, depending upon the number of intersections studied.

At this point in our program writing we could see many advantages of using our own computer personnel and equipment. During the calibration and testing period many minor adjustments were necessary. Our close working relationship with the computer section gave better control of these adjustments. These problems were not of a program writing nature but also would occur with the use of a large computer.

If we had decided to use the 704 computer, a close control of the work could only be obtained either by having a person familiar with the study area located at the computer site or by excessive and delaying cross-country correspondence.

The cost of an assignment by the 650 computer will be slightly higher than the 704 program. Using a rate of $20 an hour for the 650 computer, the cost for each assignment would be between $3,800 and $4,300. Part of this additional cost can be offset by eliminating the need of traveling to another city to have the work performed and the hiring of people to run the computer.

PROGRAM USAGE

To date two freeway assignments in both Kansas City and St. Louis have been completed. These assignments gave us traffic on arterial streets which were not available from the consultant's report. This information, while very helpful, still shows the need for future study to provide adequate capacity for predicted traffic volumes.

In Kansas City, a revised freeway plan was tested to see whether relief could be provided to certain overloaded sections of the original

freeway system. The results of this assignment show, by relocating and adding freeway links, many of the problems can and will be solved. While making these changes, we saw how the city streets were affected and tried not to exceed their capacity.

The traffic assignments in St. Louis were made basically to the same freeway system as the consultant's assignments, plus the arterial street network. This provided additional information on the arterial street system to supplement the freeway data, thus presenting the whole picture. To date, there has been no revision or additional freeway link added to the St. Louis network. At the time of this writing, peak-hour assignment is being completed for the entire St. Louis System.

Our future plans in St. Louis include a study of minor revisions in the present freeway system. Other studies are needed to determine the effects on the entire street system caused by the addition or deletion of freeway segments. In Kansas City, we plan to make a peak hour assignment and continue studying revisions in the present system.

Future plans in both cities include a revision of our zone to zone movements, making it possible to obtain a directional assignment. With the development of this program the Highway Department hopes to use it on other cities in the state. Except for Kansas City and St. Louis, all cities within the state are small enough that a barrier should not be needed for the program.

By eliminating the barrier, the time required to complete an assignment will be substantially reduced.

SUMMARY

A transportation study is now being conducted in Joplin, one of the state's larger small cities. We hope to assign traffic to the arterial street network by use of this program without using a barrier. If this method proves satisfactory, we hope to study further and develop our program to the point of assigning traffic directionally. We feel Joplin is small enough (population 40,000) to allow further program research and development at a reasonable cost.

The development of the 650 traffic assignment program has given the Missouri State Highway Department a useful tool to study urban traffic problems. For cities as large as Kansas City or

St. Louis, the 650 computer may not be the most economical piece of equipment, but it has given the Highway Department a practical method of analyzing problems of this type.

The direct comparison of time or costs for two types of computers does not always reflect the true value derived from an assignment. There are other factors to take into consideration. Program control and reliability of data are two important items. By having the computer equipment within the Highway Building, complete control of our program operations is assured. Program control is almost a necessity for accurate and reliable data.

The barrier technique has overcome a major obstacle that for so long blocked the path for successful use of the small computer. We now have a program that is capable of making a traffic assignment to any city in the state regardless of size.

As is the case many times, the more one works with a project, the more he realizes how little is actually known about his subject. This has been true in working with these traffic assignments. It has shown a great need for further research and development. Many factors relating to control of lane capacity are major problems confronting us. We need a method other than recycling to control the amount of traffic assigned to any individual street.

Using a smaller city, such as Joplin, we hope to explore these unsolved problems. With continued effort on our part, some day these problems possibly will be overcome, just as the small computer capacity has been overcome.

The Houston Transportation Study: O-D Survey Procedures

J. E. WRIGHT

Mr. Wright has been Traffic Survey Manager for the Texas Highway Department for seven years. Previously he planned and directed five metropolitan area traffic studies in Texas. He is a member of the Institute of Traffic Engineers, President of the Texas Section of ITE, and a member of Project Committee Two, Department of Traffic and Operations, Highway Research Board.

HIGH speed computer-programs, recently developed, significantly increase the value of transportation study data, particularly origin-destination information in metropolitan areas. These programs make possible the expansion of voluminous interzonal movements to future volumes based on the differential growth in each zone.

Acceptable methods of forecasting, available for years, required a volume of time and manpower that precluded their use. With new computer programs, future forecasts can be accomplished with a minimum of hours and cost.

The actual application of existing and forecasted origin-destination information has been highly restricted by the volumes of data. Past origin-destination surveys have been typified by expenditure of much time, money, and effort in the accumulation of trip-information and the transcription and manipulation of data. The result was often a report of insufficient applied traffic information and an abundance of charts, maps, and photographs. Due again to the availability of high speed computer programs, these large volumes of interzonal movements can be assigned to an arterial and expressway network with minimum time and costs.

Origin-destination information can be economically applied to the purpose for which it was primarily obtained. And just as important, results can be obtained in a more complete form while the data are current, and when the need is evident.

Another problem of origin-destination data is the matter of keeping current or up-dating information already obtained.

For many years, traffic studies have been based on the premise that travel is an expression of an individual's behavior and, as such, it has the characteristics of being habitual. As a habit it tends to be repetitive and this repetition occurs in a definite pattern. It has also been determined that travel patterns from a sample will indicate the total travel of all residents of an area, if that sample is representative of, and controlled by, geographical areas of similar land-use.

If these procedures are accepted as a basis for the collection of origin-destination data, and accurate control information as to total persons, dwelling units and land use by certain areas is obtained, the original expansion from a sample is assumed to be correct.

Therefore, if in following years, current control data can be obtained, it should be possible to keep current or up-date the original information. This procedure would be limited to areas where drastic changes in land use and population distribution had not occurred.

THE HOUSTON TRANSPORTATION STUDY

On this general line of thought, and with an increasing need for current and future assignments to both the arterial and expressway system, a metropolitan area transportation and transit study was initiated in Houston, Texas. Objectives of this major undertaking were to obtain and develop facts relating to transportation in the metropolitan area, including the nature, capabilities and efficiencies of all transportation facilities and services, the characteristics of all travel, the population, land use and economy as they affect travel patterns, and the financial and governmental responsibilities as they relate to transportation facilities and services.

Study objectives included the projection of current facts developed to the year 1980, and the assignment of these data to alternate systems of transportation facilities and services; provision to maintain current transportation facts and their periodic projection from changing conditions; and the evaluation of financial, organizational and legal implications, relative cost and benefit analysis and the development of a stage construction program based on priority of need and availability of funds.

General management and control of this study was vested in a policy committee consisting of representatives of each governmental

agency making a financial contribution. Technical problems were assigned to a technical planning committee composed of city, county, state and federal officials involved in the study. The study is being conducted in accordance with the procedures outlined by the National Committee on Urban Transportation. The responsibility for final analysis of all survey data obtained in the study and the preparation of a 1980 transportation plan for the area was allocated to Houston.

The Texas Highway Department assumed responsibility for updating a 1953 metropolitan area traffic survey, obtaining necessary data from additional area included in the current study, expanding these data to 1980 volumes and furnishing technical assistance for a mechanical assignment program. Houston assumed responsibility for the remaining phases of the study.

Now, to the mechanics of up-dating, adding to and forecasting the original 1953 origin-destination survey.

The scope of this particular project included:

Updating the internal portion of the 1954 traffic survey to 1960 values.

Expansion of the area to new metropolitan limits and a home interview and commercial vehicle origin-destination survey in this added area.

An external origin-destination survey at the cordon limits of the 1960 area.

A central business district cordon count, using the same core as in the 1953 study.

Screen line validity tests for origin-destination data.

A forecast of interzonal movements to 1980 values.

The original study included an area of 315 square miles and a population of 878,000 persons in 1953. This area in 1960 with much vacant land still available, had only an eleven percent increase in population, bringing the total population to 953,000 persons.

It was also ascertained that no major land use changes had occurred and that no major area changes in industry had occurred in the original study area. Certainly there had been growth in industry and building, but this growth had occurred in areas of like land use in 1953.

The 1960 study area was determined by existing population

density, plus the area expected to develop in the next 20 years. The added area included 297 square miles and a population of 201,000 persons, bringing the 1960 study area to a total of 612 square miles and a population of 1,154,000 persons (Figure 4).

Outer or fringe portions of the 1953 area were eliminated from the 1953 data and these sections were included for study in the new area. This procedure made it possible to obtain current data in areas of large growth, where the 1953 study had only a scattered pattern of samples due to the lack of development in these areas.

This reduction of the size of the original 1953 area also lowered the 1953 to 1960 population increase to only eight percent in the area selected for up-dating.

Travel data in the new area were obtained by the usual methods of a comprehensive type, home interview origin-destination traffic study. This included the selection of a ten percent sample of all dwelling units by the field inventory method. A ten percent sample of all trucks registered within this area was also selected for interview.

Interviews of selected samples provided travel data including origin-destination, mode of travel, time of travel and purpose of trip. These data coincided with the data obtained in the original 1953 study.

The screen line used in the original study was extended through the new area and actual crossings by type of vehicles were determined by both mechanical and manual counts. Screen line comparison of actual crossings, compared to survey data in 1953, indicated eighty-six percent accuracy with no adjustment made for double crossings incurred in some movements. The 1960 screen line comparison of current crossings, with expanded 1953 data and 1960 data from the added area, indicated a ninety-one percent coverage with survey data.

A new external survey was made on the cordon line of the 1960 area. Total crossings of this cordon amounted to 136,450 vehicles a day. Usable interviews were obtained from drivers of 115,142 vehicles or eighty-four percent of total cordon volume.

The 1953 internal home interview study was developed with data obtained from sample dwelling units. This was a field selected sample, controlled and factored by individual census tracts. Total

dwelling unit and population data were obtained in this field sampling procedure. Census tracts, even though subdivided in many cases, maintained their identity in the 1960 census. This made possible a method of expanding the 1953 trip data to the 1960 level by using current census statistics in the same areas used for control of the 1953 study.

VALIDITY TESTS

The next question was the validity of adjusting the volumes of the 1953 trip pattern to 1960 values. To test this possibility, and to assist in determining factors of change, six census tracts within the original study area were selected as test tracts.

These tracts were selected on a basis of representation of geographical location, land-uses and population variation (Figure 1). These test tracts varied in population change from a thirty percent loss to a gain of forty-one percent during the 1953-1960 period. Average variation in population of these tracts was approximately the same as was found in the entire 1953 study area scheduled for up-dating.

Current travel data were obtained in each of these test areas, using standard home interview techniques, with the same sample base, five percent, as used in the 1953 study. In three tracts the original samples selected in 1953 were used for interview. New samples were selected in the remaining test tracts, also on a five percent basis. In checking locations of the new samples selected in these three test areas it was found that over fifty percent of the samples selected in 1960 were identical to dwellings selected in the 1953 study.

Information was obtained from each sample to determine the occupancy of the dwelling units in 1953 and in 1960. It was found that forty-nine percent of the sample dwelling units in the test tracts were occupied in 1960 by the same families living there in 1953.

Comparisons of various data obtained from the six test tracts in 1960 were made with the original 1953 study area as a whole and with the data from these test areas as they appeared in 1953. This information was also compared to similar correlations obtained in the new area added to create the 1960 metropolitan area. Table I indicates the close relationship of the 1953 and 1960 data.

Persons per dwelling-unit seem to be a fluctuating factor, particularly by areas. Automobiles per dwelling unit also varied by area but show an increase during the seven-year period. Total trips and automobile trips per dwelling unit would naturally vary with the change in number of persons per dwelling unit. Total trips per person and automobile trips per person show a definite pattern and trend, however.

TABLE I—COMPARISONS OF BASIC DWELLING UNIT DATA*

	Persons Per Dwelling Unit	*Autos Owned Per Dwelling Unit*	*Total Trips Per Dwelling Unit*	*Auto Trips Per Dwelling Unit*	*Total Trips Per Person*	*Auto Trips Per Person*
1953 Study Total Area	3.2	.94	7.2	3.8	2.2	1.17
1953 Study Test Tracts Only	3.2	.99	7.7	4.5	2.4	1.42
1960 Study Test Tracts Only	2.8	1.07	7.0	4.3	2.5	1.53
1960 Study New Area Only	3.4	1.28	8.8	5.4	2.5	1.55

* Showing relation of persons, dwelling units, automobiles and trips by various areas for 1953 and 1960.

Previous studies of urban vehicle miles in Texas have also indicated a definite pattern in vehicle trips per person, particularly when controlled by cities in their particular population group.

These data substantiate the possibilities of expanding origin-destination information on the basis of known population changes and trends in trip per person. This, of course, is dependent on the original pattern of trip information remaining constant or at least within an acceptable range of accuracy to produce reasonably reliable assignments for route location and design.

A comparison of the 1953 trip pattern of the test tracts expanded by 1960 population data and the pattern of the same areas, as developed from 1960 interviews, is shown in Figures 1 and 2.

An analysis of the tabulations from which these desire line presentations were prepared shows that all major movements are included in both the expanded and current data. There is a variation in single samples, and scatter pattern trips. Volume variations are apparent in some movements. It is believed, however, that the basic pattern of the two studies proves the acceptability of the expanded data.

Since it is planned to forecast the interzonal movements of the up-dated study to 1980 volumes by the probable differential growth in each zone, it is believed that the existing volume variations are insignificant and will adjust to the future forecast properly.

The primary purpose of the origin-destination survey is to obtain information on which to base route locations and design data. In this particular city, routes are generally located, but information on which to base the location and design of interchanges is most important.

To further test both the pattern and volume of the up-dated data, assignments were made to the proposed expressway system. Identical procedures were used to assign the expanded 1953 and the 1960 interzonal movements from the test areas to the network. The maximum mean variation on any route was found to be 14 percent. This maximum variation was found on the outer loop of expressways with attendant low volumes due to the location of test tracts. Current data from the added portion of the study will eventually furnish a majority of the assignments to these perimeter locations rather than the original study data.

Figure 3 shows the assignment of the up-dated 1953 data from the six test tracts to the proposed expressway system. Percent variation of assignments of movements obtained in the current study of these same areas is indicated on each route.

This would further indicate that the difference between the pattern of current interzonal movements and up-dated 1953 movement is insignificant. It indicates also that the up-dating procedures based on population changes have maintained very close volume alignments with current data.

Shown in Figure 5 are a comparison of trip purpose distribution by mode of travel for the total area of the 1953 study, the six test tracts in 1953 and the six test tracts in 1960. Again certain variations are evident, but no major change seems to have occurred in either automobile driver characteristics or for all modes of travel.

As mentioned previously, sampling in the added study area was done by an actual field inventory of dwelling units, controlled by census tracts. Each tenth dwelling was selected for interview. Interviewers obtained data relative to total persons living at each sample dwelling unit. This information was expanded to develop total population by census tracts. The 1960 census was made in

these same tracts approximately two months before the sampling and home interview work was conducted by traffic study personnel.

Preliminary census data were obtained for the Houston area from the Census Bureau soon after their field work was completed, and these data were compared to the expanded population figures obtained by the survey in the new area of the study. This comparison showed only a two percent variation in the total population of the area as obtained by the two different agencies. This surely indicates the accuracy of data that can be obtained by the sampling method, if proper control of methods and areas are maintained.

UP-DATING PROCEDURES

Analysis of the various tests made between the 1953 and 1960 data in the six test tracts indicated sufficiently close comparisons of pattern, purpose and volume of interzonal trips to indicate the feasibility of up-dating the 1953 study with acceptable results.

Factors of change were developed for each census tract in the original area based on population variation. Test data indicated an eleven percent increase in automobile-driver trips per person and a five percent increase in automobile-passenger trips per person during the 1953 to 1960 period. Mass transit trips from the original study were not included in the up-dating procedures due to the availability of current O-D transit information from a study in progress by a consulting firm. These data will be incorporated in the reports of the current study.

Automobile-driver trips obtained in the 1953 study were given new factors developed by the following formula.

$$\frac{\text{1960 Population}}{\text{1953 Population}} \times 1.11 \times \text{1953 Factor} = \text{1960 Factor.}$$

This same procedure was used for up-dating the 1953 automobile-passenger trips by substituting a 1.05 percent increase in trips per person between the 1953–1960 period for these trips. As mentioned previously, original factors were controlled and developed by census tracts. This same control was used in developing the 1960 factor.

The up-dated information was then merged with the current data obtained in the added area. The average trip factor developed

in the up-dated procedure was 28.4 as compared to an average factor of 20.5 used in 1953. The average factor for the added area was 10.6.

Commercial vehicle trip data from the 1953 study were up-dated by a factor developed from the increase in the number of registered commercial vehicles in the old area between 1953 and 1960. This increase amounted to approximately 25 percent, which changed the 1953 factor of 9.7 to a value of 12.1 for 1960. The up-dated 1953 data were supplemented by current interviews with 10 percent of the commercial vehicle operators in the added area.

A comparison of the number of licensed taxicabs operating in the area in 1953 and in 1960 showed no appreciable change. Average daily trips per taxicab also showed no basic change, so the 1953 taxicab data were accepted as valid for use in the 1960 study.

Procedures outlined to this point developed a comprehensive study in an area of over 600 square miles with a population of 1,154,000 persons, and provided a current total of over 2,000,000 vehicle trips for basic analysis, expansion and assignment.

The O-D Survey, including field work, analysis, a basic report and forecasting, will cost less than $100,000.00. This is less than one half the estimated cost of a completely new survey. It is believed that the data developed by these procedures are within very close limits of information that would have been obtained in a completely new study.

FORECASTING

A major phase of the Houston Transportation Study has been conducted by the City Planning Department. Current land use and population distribution data have been obtained and prepared by census tracts and by O-D Survey zones. This information will be the key to future forecast of interzonal trip data.

Total vehicular trip-ends by each zone have been obtained from the combined up-dated and current O-D data. Trip-ends have been accumulated and classified as automobile or commercial vehicles. Automobile trips, which include taxicab movements, have been subdivided into those with a trip purpose of "from or to home" and those with other trip purpose.

The probable 1980 population by each zone has been predicted

by the planners. Also the land-use for each zone has been classified as residential, retail, commercial or industrial as it exists now and the 1980 changes predicted.

The 1960 trip-ends as developed by existing land use will be expanded in 1980 values on the basis of estimated land use change in each zone. An additional factor will be used to adjust for the increasing trend of vehicle trips per person. Based on available data for the past seven years this factor will probably amount to about 1.5 percent a year.

ASSIGNMENT

Low density zones have been combined with neighboring zones of similar characteristics to alleviate the difficulties, inherent to growth factor methods, caused by interzone volumes of zero. This zone combination also makes possible a more equitable distribution of trips to the arterial and expressway system in the development of the assignment program.

After the forecast has been completed, trip volumes may be prorated back to the original small zones if such a distribution is desirable or necessary to properly located centroids to fit the proposed network.

Current and expanded interzonal vehicular movements will be assigned to a proposed arterial and expressway system by available computer programs. First assignments will be non-directional, since peak hour and directional data are considered adequate in the area to develop design hour volumes.

CONCLUSIONS

Additional assignments will be made to revised systems, as dictated by the results of the first runs. No capacity controls will be used on routes, in order that actual desired movements, based on minimum time paths, will be developed. Routes with over capacity loadings will be studied by use of the selected link assignment. This additional feature of the assignment program will indicate the origins and destinations of all assigned trips to selected links of the system, allowing changes to be made to relieve critical situations.

Obviously, additional research is certainly desirable and even necessary to develop better methods of procuring O-D information and forecasting these data. Unfortunately, we cannot wait until

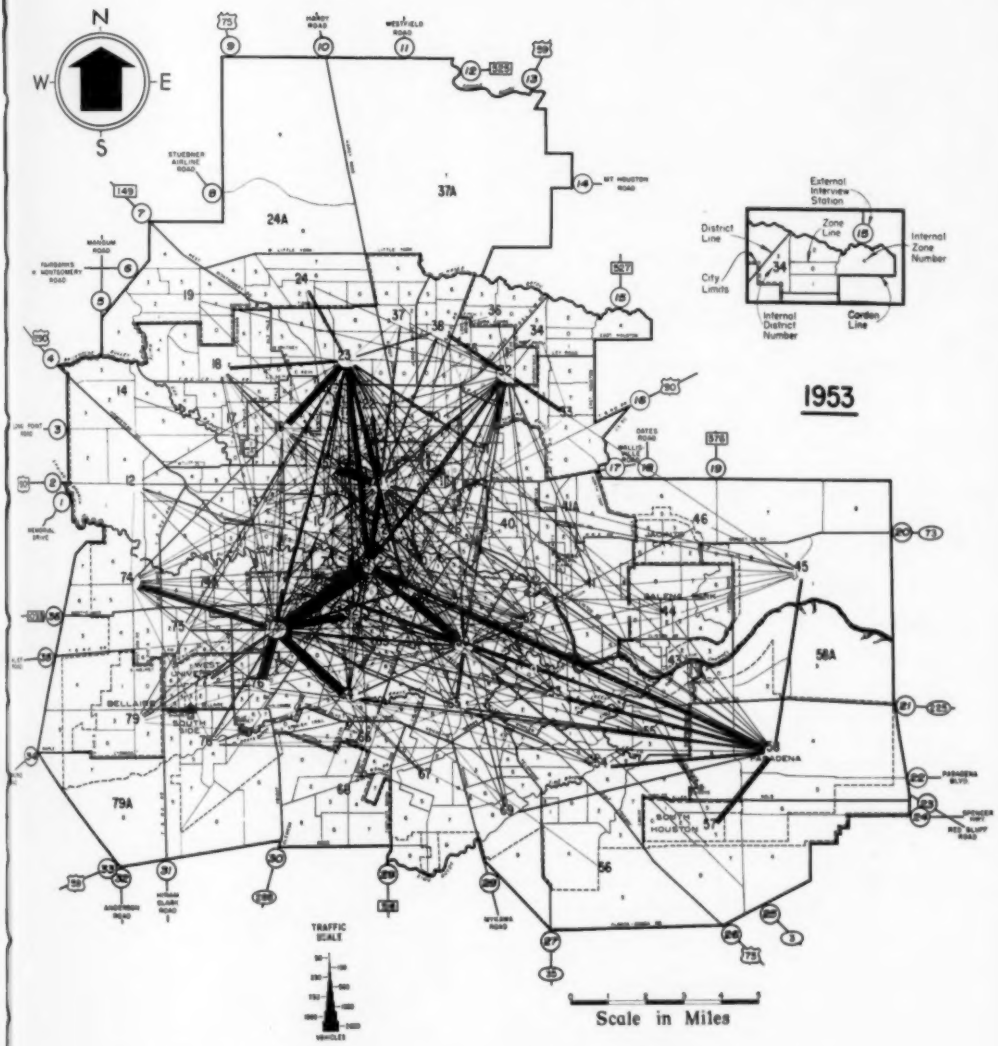


Figure 1. Desire Line Chart Showing 1953 Vehicle Trips Generated by Test Areas, Expanded to 1960 Values by Current Census Data.

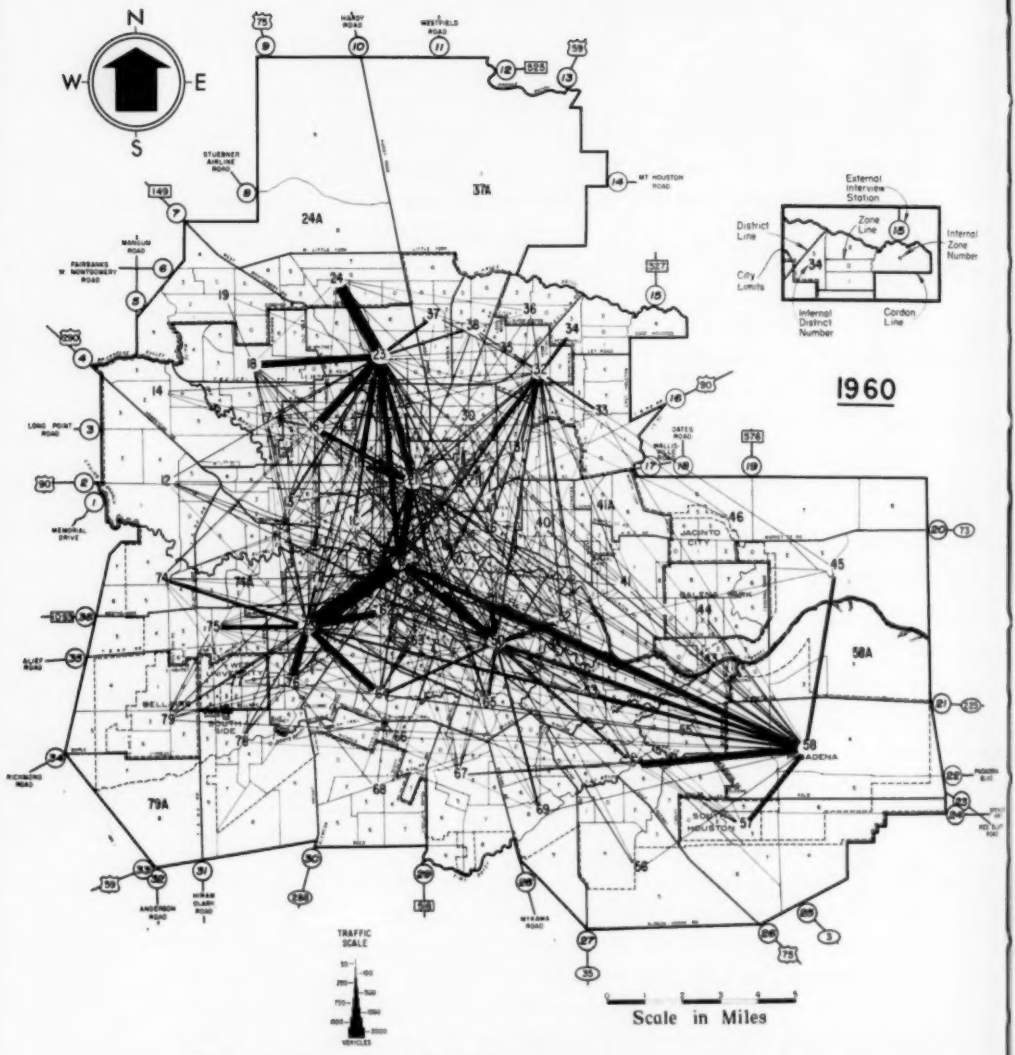


Figure 2. Desire Line Chart Showing 1960 Vehicle Trips Generated by Test Areas, as obtained by Current Interviews.

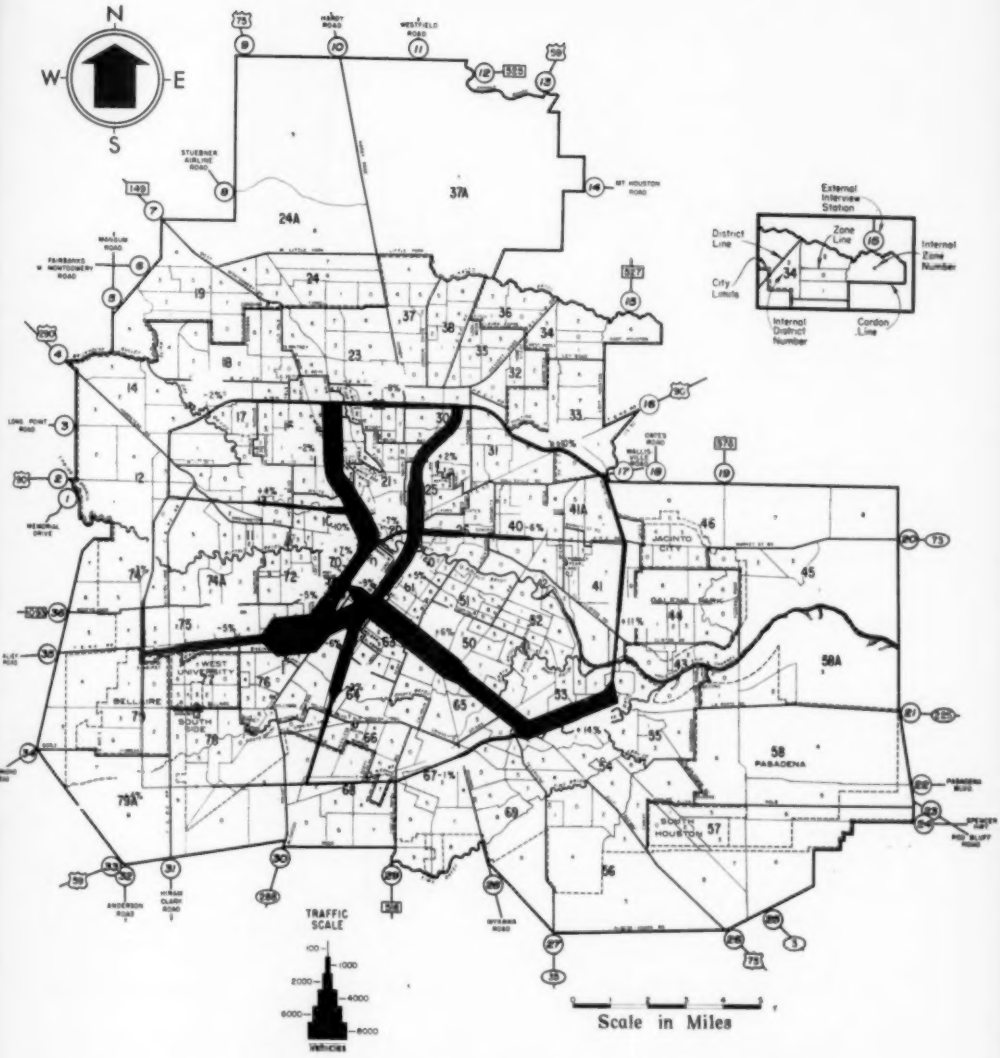


Figure 3. Assignment of Vehicle Trips, Generated by Test Areas, to Freeway System, Showing Maximum Mean Variation of Assigned Volumes Between Expanded 1953 Data and Current 1960 Data.

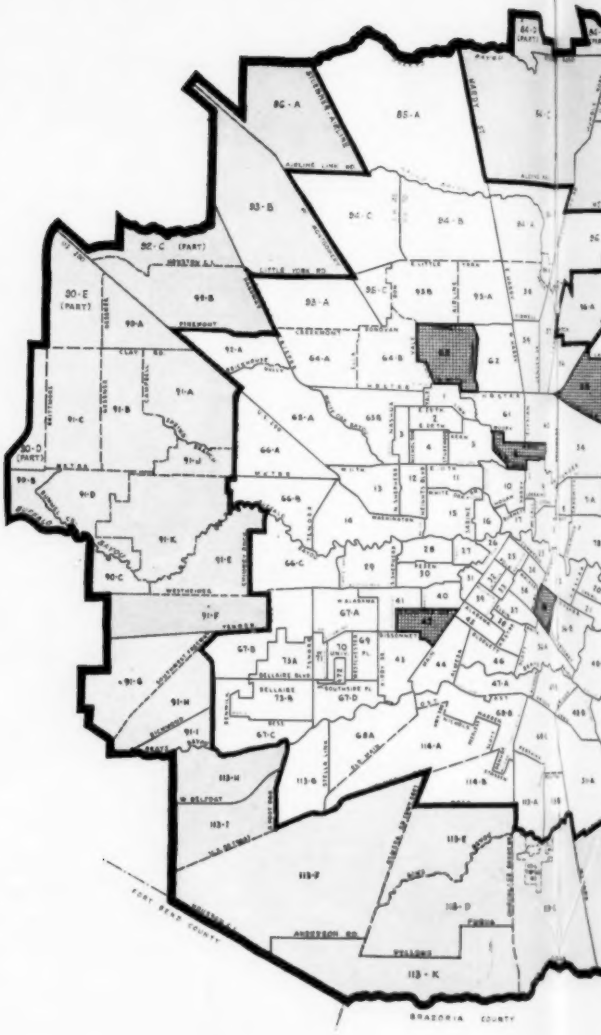
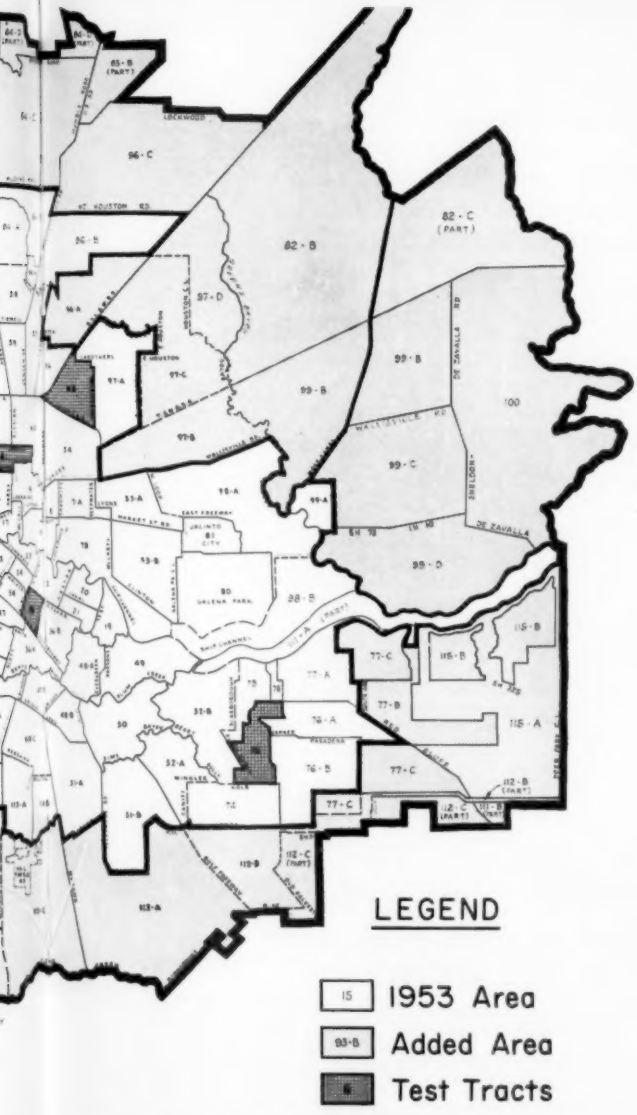


Figure 4. Census Tracts. The Study Area i
for the 1960 Study and Locat



Study Area in 1953, Additional Area Added
dy and Locations of Test Tracts.

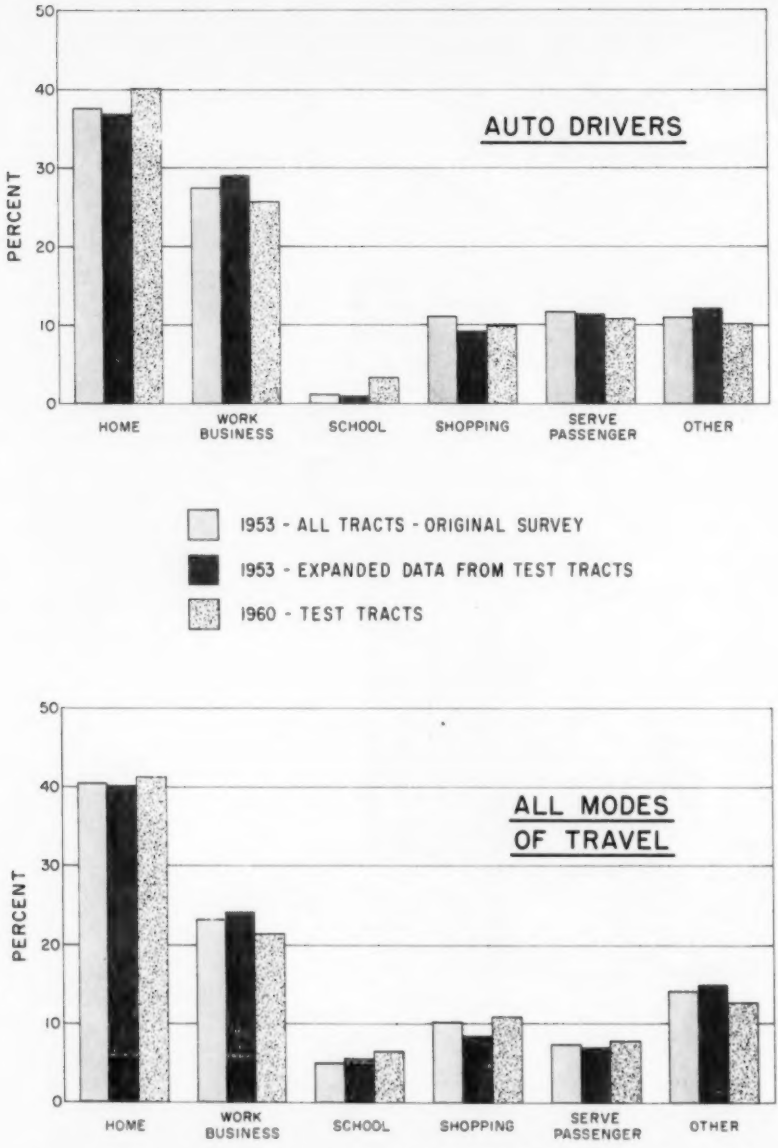


Figure 5. Comparison of 1953 and 1960 Trip Purpose Distribution for Automobile Drivers and for All Modes of Travel.

Figure 6.

Figure 7.

such Utopian methods are fully developed to locate and design the facilities needed today and tomorrow to handle the tremendous load of current and expected traffic.

The pressing need of information upon which to base current projects forces the use of not only the best methods presently available, but methods that permit us to furnish these necessary data now, when most needed.

The Houston study will make available, in less than one year from the beginning of field work, 1980 vehicular assignments to a comprehensive network of arterials and expressways in the area. It is believed that, even with the minor variations possible in the methods used in this study, it is worth some sacrifice to be able to furnish the data *now*.

The Rapid Transit District Project Of the San Francisco Bay Area

HENRY D. QUINBY

Mr. Quinby is Principal Transportation Engineer with Parsons, Brinckerhoff, Quade and Douglas, Engineers, New York and San Francisco. He is in charge of the transportation and traffic engineering studies for Parsons-Brinckerhoff-Tudor-Bechtel, the joint venture engineering firm that serves as general engineering consultants to the San Francisco Bay Area Rapid Transit District. He has been associated with that project since the commencement in 1953 of engineering studies concerning it. In 1956 Mr. Quinby was on leave of absence from his firm to study and observe transportation planning and transit operations in twenty European countries. Among other pertinent experiences, he served as consultant on transportation studies in Dayton, Ohio, and Hamilton, Ontario, and the direction of studies of vehicular traffic control equipment, parking, intersection channelization, and toll facilities traffic and revenue. He is a member of the American Society of Civil Engineers and of the Institute of Traffic Engineers.

STUDIES in progress in the San Francisco bay area may contribute significantly to enhancing public transportation as an element of this country's metropolitan circulation facilities. The trend of general decline in metropolitan mass transit in the United States for more than thirty years may be reversed as a result of effective, modern rapid transit, such as the regional system planned for the San Francisco Bay Area.

Rapid transit—defined as a public mass transportation system distinguished from other transit by its operation at relatively high average-speeds over generally exclusive, grade-separated rights-of-way—first made its appearance in the latter part of the nineteenth century. Before the automobile became a principal mode of travel, the almost exclusive use of transit facilities naturally promoted, by demand and favorable economic circumstances, the development of rapid transit projects. The period before 1920 witnessed the construction of subway systems in Boston, New York, and Philadelphia, and elevated lines in these cities and in Chicago as well.

As the automobile came into popular usage, growth of rapid

transit systems slowed. From 1935 to 1955 there was actually a net decrease of nine miles in reported subway and elevated trackage. Patronage in the same years, particularly outside the weekday peaks, showed a general decline except during World War II. Only recently have large cities in this country taken major steps looking toward the rejuvenation of rapid transit as an element of their total transportation requirements.

The principal metropolitan centers of the western world have certain characteristics in common. Typically, the focus of the cluster of communities comprising the metropolitan area is a concentrated core in which specialized, highly diversified services for the entire area are provided. Sub-centers, primarily of importance to their immediate area, are distributed at some distance from the core. A complex interrelationship and interdependence exists throughout the area, keyed by the region-wide influence of the central core.

As functions of our civilization have become more specialized, and as our interests have diversified, we have become increasingly dependent upon one another for goods and services. This interdependence is most often satisfactorily resolved through face-to-face communication. It is principally this capability that is the *raison d'etre* of the metropolitan core. As its activities change and become more complex, it should increase in density and/or area, for the capabilities of focus, market place, selection, specialized function, and personal contact must not be lost.

Simultaneously, as individuals we have not lost our yearning for open land. As metropolitan regions develop, central residential areas become more and more oriented towards low and high income extremes, while the mainstream of population growth is absorbed by a wave of expanding suburban development, continually reaching farther away from the central district in which nighttime population tends to stabilize or decline.

Thus, to an increasingly great extent, sub-regional centers and the central core both draw on the suburbs for their labor supply. The tantalizing dislocation between the general residential desire for open land and the general business desire for intimate communication continually broadens and lengthens the task of the metropolitan transportation system. Especially on the west coast, and to an equal or lesser extent elsewhere, we have been relying more and

more upon the automobile as our prime metropolitan transportation link.

But an eventual consequence of large-scale metropolitan growth is the almost inevitable necessity to upgrade public transit facilities so that they may more effectively complement the expanded highway networks in meeting the burgeoning circulation requirements. Where, as in most major metropolitan areas, the problem is large, rapid transit is generally the most logical choice for further study and development in this direction, because it is uniquely suited to transport quickly and conveniently large masses of people to and from concentrated areas.

The often-made comparison between the capacity of a single rapid transit track and the capacity of a single freeway lane carrying automobiles, or even buses, illustrates rapid transit's frequent suitability and economy as a heavy-traffic corridor element.

Even more important is the fact that rapid transit can, by a series of stations, deliver these volumes conveniently—in predictable travel-times—to the heart of a metropolitan core without preempting a major proportion of the core area for the freeways, streets, ramps, and loading and storage space that the automobile and, to a lesser extent, the bus require. Its efficiency of passenger delivery is likewise important to the several regional sub-centers it serves.

Evidence that the importance of rapid transit is increasing may be seen in a number of North American cities. Cleveland and Toronto both have new, modern rapid transit systems. The Cleveland transit system's rapid transit route is particularly noteworthy for its development as a trunk line and the extent to which park-and-ride facilities are utilized.

The Chicago transit authority is well known for its study of light-weight, high-performance rapid transit equipment. Its new freeway-median route has provided dramatic comparisons of rapid transit's effectiveness, and, based largely on these results, more such routes are actively planned. Such routes typically operate at a relatively small percent of their potential capacity, yet carry more passengers past critical load points in peak periods than the accompanying traffic-saturated freeways.

In New York, important progress in train control has been made with the development of completely automatic operation of

a shuttle train. Semi-automatic operation has been in effect in Stockholm for more than a decade.

The resurgence of interest in rapid transit may be attributed in some degree to growing acceptance of the fact that the automobile is not always capable of solving some of the most serious transportation problems in major population centers. It may be attributed also to the accelerating and successful evolution of rapid transit methodology.

As planned for a modern metropolitan area of the western world, with its high ratio of automobiles to population, rapid transit cannot be generally or ultimately limited to the confines of the central city. Conceived as a regional system it exerts its influence—often even its principal influence—in the widespread suburbs and intercepts critical commuter automobile trips, thus relieving the highways for movements that must be made by motor vehicle.

On the west coast, with limited exceptions, the automobile has dominated transportation throughout most of the period of metropolitan growth. The effect on land use has been a generally broader, less dense development, with the characteristic association of related land use elements somewhat more dispersed. In its extreme form, this trend is typified by the vast sprawl of the Los Angeles metropolitan area.

In the San Francisco bay area, geography has tempered the tendency to urban sprawl. Surrounding hills have concentrated major growth among the cluster of cities along the water, while the Bay and hills together have restricted the endless multiplication of streets and highways.

Thus, limited space and few transportation corridors have concentrated and channelized urbanization. At the same time they have increasingly impinged on free inter-communication. Soon after World War II, bay area leaders began to recognize the need for a mass transit facility capable of easing the burden on automobile facilities and providing convenient movement, especially for commuters, throughout the region.

In 1949, the California state legislature enacted the San Francisco bay area metropolitan rapid transit district act, and in 1951, created the San Francisco bay area rapid transit commission, the SFBARTC. The commission's findings recognized the insufficiency

of highway programs in solving some of the bay area's most pressing transportation problems, and recommended the construction of a modern, convenient rapid transit system. Their report outlined the steps necessary to develop such a system.

The first of these steps was undertaken in 1953, when the State Legislature extended the life of the SFBARTC. A firm of engineering consultants for the commission began studies for a regional rapid transit system. Preparation of a comprehensive current and future land use plan for the nine participating bay area counties was undertaken. In the Spring of 1954, a regional origin-destination survey was conducted.

These data, complemented by the results of the updated bay area metropolitan traffic survey and a predictive analysis of future Bay Area interzonal movements, provided the basis for development of traffic, revenue, and operations forecasts for present and future years. Transit methods and routes capable of meeting forecasted traffic needs were studied.

The engineering consultants published their report in January, 1956. In it, they outlined the plan for phased construction of a comprehensive regional rapid transit system, and presented preliminary plans, including cost and revenue estimates, for a first stage system, to consist of 123 miles of grade-separated rail routes, linking San Francisco and Oakland, and extending north and south on both sides of the Bay, as well as eastward into central Contra Costa County. In March of that year, a research institute published its report on the organizational and financial aspects of the proposed system.

The engineers' report emphasizes that "the existence of the large group for whom only the private motor vehicle provides effective transportation dictates a strong highway system as the very first requirement in satisfying over-all transportation demand."

It continues by pointing out that "the total transportation system must comprise a comprehensive network, so combining automobile and transit facilities that each can serve adequately that part of the total demand for which it is best suited. And it is equally important that each portion of the transportation demand be served by the facility type that can most economically be constructed to the required capacity."

As a result of these studies under the SFBARTC, the California

state legislature acted further in 1957, creating the present San Francisco bay area rapid transit district (SFBARTD), comprised of the counties of San Francisco, San Mateo, Marin, Alameda, and Contra Costa. This district is charged with the task of developing and putting into operation a system of interurban regional rapid transit for its five counties.

Provision is made for the admission of other, peripheral, Bay Area counties as circumstances indicate. In 1959, the legislature pledged conditionally the excess toll revenues of the San Francisco-Oakland bay bridge to the financing of the transbay tube between downtown San Francisco and Oakland, as the central link in the proposed system.

In Los Angeles as well, plans for rapid transit were underway. Faced with a Los Angeles central business district in which fully two-thirds of the land area has been usurped by freeways, streets, parking, and loading facilities, civic leaders have realized the necessity for an effective mass transit system. The Los Angeles Metropolitan Transit Authority (LAMTA), created by the California State Legislature in 1953, is responsible both for the operation of mass transit and for the future development of rapid transit facilities.

At first limited to studies of monorail, LAMTA in 1957 was given a broader scope, including expansion of its territory to include all of Los Angeles County. The authority recently received a preliminary report from its consultants, who studied types of systems, location of lines and stations, and the probable cost for constructing a modern rapid transit system.

In San Francisco, the SFBARTD is now completing plans for the proposed Bay Area rapid transit system. During the last two years, the joint venture engineering firm has been engaged in studies leading toward adoption by the district of a recommended rapid transit system.

These studies were founded upon and to some degree were a continuation of SFBARTC's 1956 report. Areas of study were numerous. A detailed evaluation of potential routes was made, with regard to service provided, right-of-way acquisition cost, construction cost, and feasibility. This work was carried out with the continued close cooperation of the planning and engineering staffs in the communities to be served.

A special study by noted seismologists was undertaken to deter-

mine the effects earthquakes may have on design of the transbay subaqueous tube. Tests have indicated that normal design will provide adequate protection from earthquakes. Another study by a suspension bridge authority established the feasibility of using the Golden Gate bridge for rapid transit operation. Representative track and station plans have been prepared, and detailed construction cost estimates completed. Transportation engineering studies have included complete estimates of patronage, fare structure, revenue, system operation, train schedules, operating expense, and requirements for rolling stock and yards.

An evaluation of the economic effect which the system will have on the Bay Area is in progress, and studies analyzing the financing arrangements that will be required to implement construction of the system are nearing completion.

The plan has undergone the critical scrutiny of agencies of the counties and cities it is to serve and has been modified as appropriate to meet the comments of these groups. Once the financial studies are completed, the program must be approved by the Boards of Supervisors of the five counties and a general obligation bond issue for construction endorsed by an over-all two-thirds vote in those counties. The election is expected to take place in 1962.

The plan calls for a mainline express interurban rapid transit system composed, in its general first stage, of somewhat over 100 miles of double track variously situated in subway, tunnel, and tube, on grade, and on aerial structure, with complete separation from all other traffic. Its principal link is to be the six-mile transbay tube and approaches connecting downtown San Francisco and Oakland, via Market Street and Broadway, respectively.

The San Francisco route will extend southward from the Civic Center through Daly City and down the peninsula to Redwood City and Palo Alto. A second route will extend from downtown San Francisco westward, thence across the Golden Gate Bridge to just north of San Rafael in Marin County. From the Oakland central business district, routes will extend southward in Alameda County to Hayward and Fremont, northward to Richmond, and eastward in Contra Costa County to the vicinity of Concord.

Over these routes, trains up to ten cars in length, and capable of eighty-mile-an-hour maximum speeds, will average approxi-

mately forty-five miles an hour, including station stops. During peak periods, service at intervals as frequent as ninety to 120 seconds will be attained. A completely automatic system of train control, utilizing a central computer, is planned. The computer is expected also to perform accounting functions and to control a system of automatic credit fare collection. The latter feature will be of obvious appeal to commuters.

Auto-dominated growth has shaped the form of the projected rapid transit system, which will consist of interurban trunk lines configured to attract and serve automobile trips of interest well outside the metropolitan core.

In downtown San Francisco and Oakland, stations will be conveniently located for pedestrian access to most destinations, but suburban stations will be more widely spaced, being designed to serve suburban business districts and residential tributary areas of as much as four to six miles in radius, due to the low-density character of modern auto-scaled suburban communities.

The resultant average station spacing for the entire system will be approximately 2.3 miles. This relatively wide spacing of stops, and the use of modern rolling stock, permit average speeds and commuter travel times truly competitive with the automobile.

Again because of the low density of tributary areas, most rapid transit patrons will require some form of feeder transportation to reach rapid transit stations. For many potential riders, the automobile will best serve this purpose, because of its customary past use for their total transportation needs. This use of the automobile as a rapid transit feeder at suburban stations will be facilitated by provision of adequate free or low-fee parking space conveniently situated adjacent to the stations.

The success of this scheme has been well proved in Chicago, Boston, and Cleveland. The expectation is that small automobiles will find increasing favor for the home-to-station trip. Most of these same suburban rapid transit stations will be served also by some form of feeder transit.

Thus rapid transit will be most effective not by replacing the automobile but by complementing it particularly for those concentrated commuter movements where vehicular congestion impairs the automobile's effectiveness. The proposed system has been

planned to provide the peak period commuter in particular with door-to-door travel-times and out-of-pocket travel costs comparable to those of the automobile operating over the bay area's future networks of freeways, streets, and highways.

Justification of rapid transit as a traffic facility depends upon its ability regularly to attract to its use many potential trips of interest which may optionally use automobiles. Only by diverting a large proportion of such uncommitted potential trips can it achieve a sufficiently high patronage level for economic operation and for a significant alleviation of vehicular congestion.

While rapid transit must meet the test of engineering feasibility and must be financable, its main justification, after all, is its effectiveness and economy as a transportation facility. Transportation and traffic studies have, for that reason, been one of the important areas of activity throughout the planning phase of the bay area project.

Forecasted future regional land use, traffic patterns, and physical features indicated the best general location for each route; potential passenger volumes indicated the general type of transit facility needed. Estimates of rapid transit patronage and of total Bay Area travel measured the capability of rapid transit in maintaining free traffic flow.

The patronage, revenue, and operating expense estimates have also been important elements in the economic studies for the project.

With significant decisions resting upon the results of these transportation and traffic studies, they naturally involved considerable refinement both in method and detail. The work was divided into several phases. Some of the noteworthy aspects of the resulting analyses are described in the paragraphs below.

As source material, the regional planning study and the two major origin-destination surveys already noted were available. One of the first tasks of the current project was the up-dating of this earlier O-D data to the 1959 level. Used to update these surveys were recent vehicular traffic counts, auto registration records, and transit data. The O-D volumes and patterns thus updated were carefully checked against recent limited-purpose O-D surveys by others and against other material.

Because of the relatively rapid population and economic growth

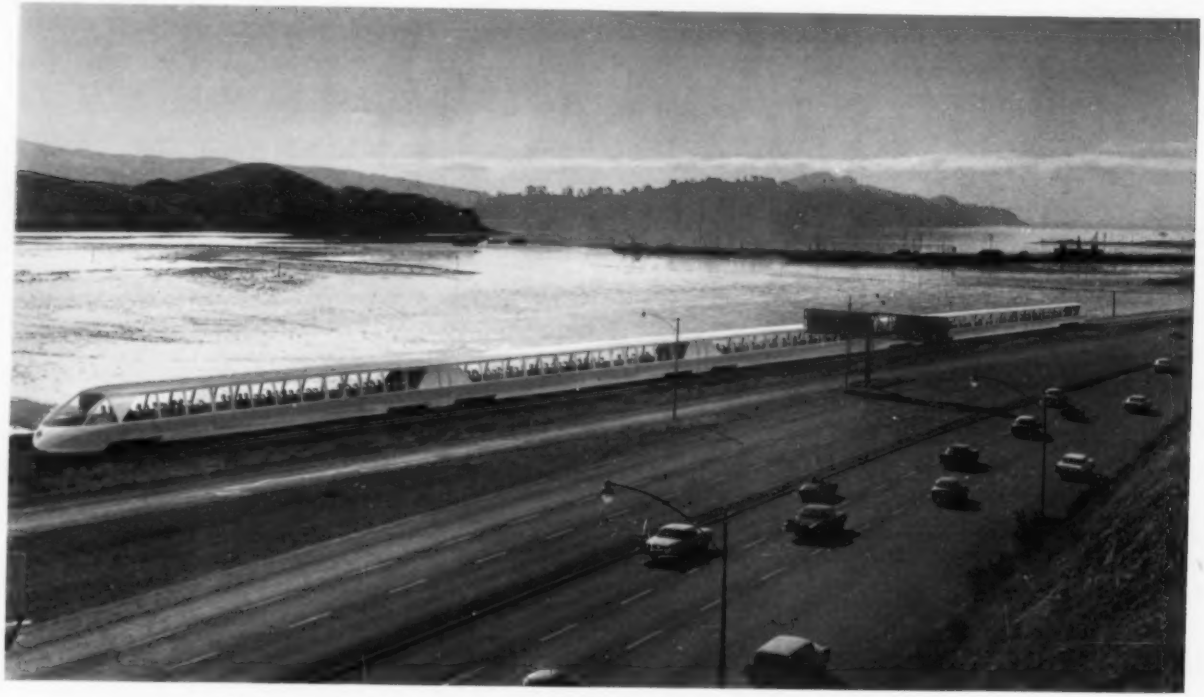
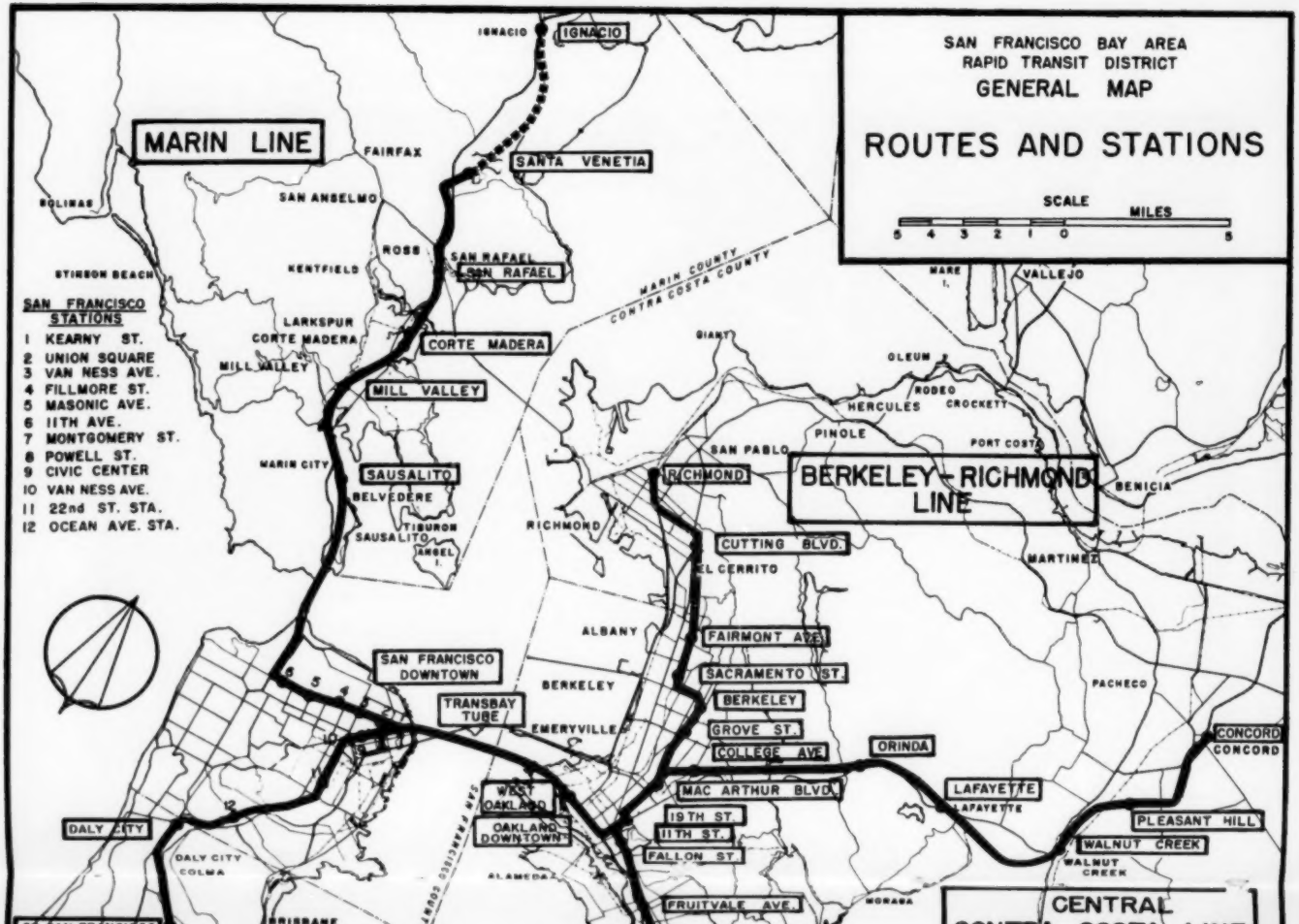


Figure 1. Conception of a Rapid Transit Train on Proposed Marin County Route Alongside U.S. 101 North of San Francisco.


SAN FRANCISCO BAY AREA
RAPID TRANSIT DISTRICT
GENERAL MAP
ROUTES AND STATIONS
SCALE
MILES
5 4 3 2 1 0 5
MARIN LINE
BERKELEY - RICHMOND LINE
CENTRAL
SAN FRANCISCO STATIONS
1 KEARNY ST.
2 UNION SQUARE
3 VAN NESS AVE.
4 FILLMORE ST.
5 MASONIC AVE.
6 11TH AVE.
7 MONTGOMERY ST.
8 POWELL ST.
9 CIVIC CENTER
10 VAN NESS AVE.
11 22nd ST. STA.
12 OCEAN AVE. STA.
IGNACIO
SANTA VENETIA
FAIRFAX
SAN ANSELMO
ROSS
SAN RAFAEL
KENTFIELD
LARKSPUR
CORTE MADERA
MILL VALLEY
MARIN CITY
SAUSALITO
BELVEDERE
TIBURON
ANGEL I.
BOLINAS
STINSON BEACH
MARIN COUNTY
CONTRA COSTA COUNTY
MARE I.
VALLEJO
GIANT
OLEUM
RODEO
CROCKETT
HERCULES
PINOLE
PORT COSTA
SAN PABLO
RICHMOND
BENICIA
MARTINEZ
CUTTING BLVD.
EL CERRITO
ALBANY
FAIRMONT AVE.
SACRAMENTO ST.
BERKELEY
GROVE ST.
COLLEGE AVE.
ORINDA
PACHECO
CONCORD
LAFAYETTE
PLEASANT HILL
WALNUT CREEK
MAC ARTHUR BLVD.
19TH ST.
11TH ST.
FALLON ST.
FRUITVALE AVE.
SAN FRANCISCO DOWNTOWN
TRANSBAY TUBE
EMERYVILLE
WEST OAKLAND
OAKLAND DOWNTOWN
ALAMEDA
DALY CITY
COLMA
MONTARA

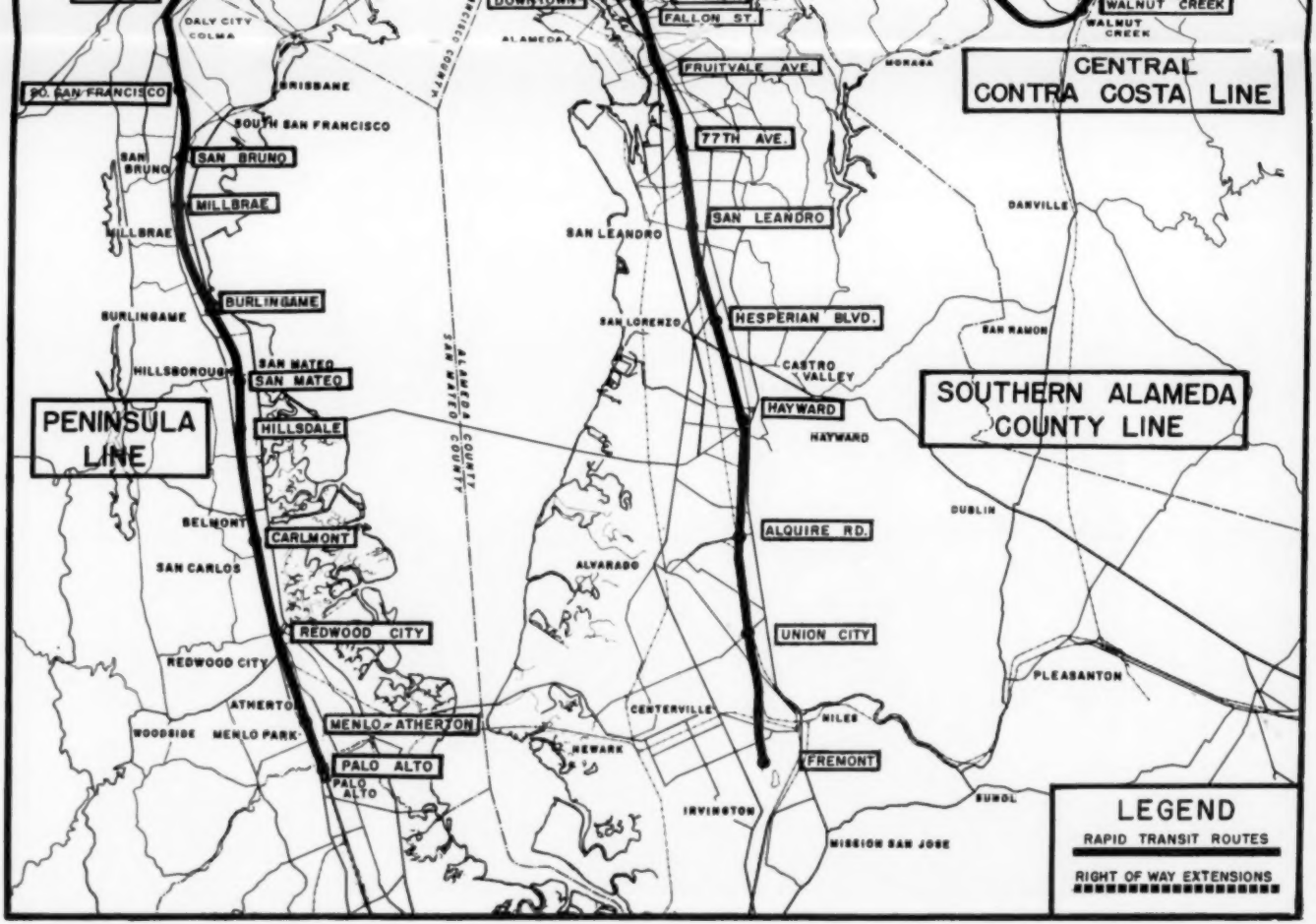


Figure 2. Routes and Stations Proposed for the First General Stage of the San Francisco Bay Area Rapid Transit System.

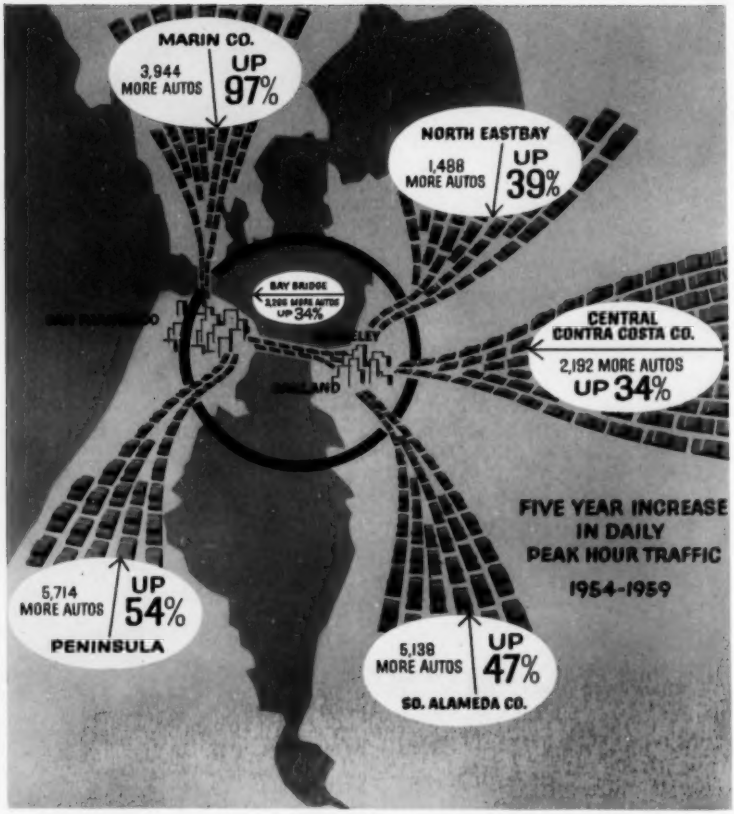


Figure 3. Schematic Indication of Recent Peak Period Vehicular Traffic Growth at Six Major Bay Area Gateways.

forecast for the bay area, and the consequential significant effects on traffic patterns during the future years of rapid transit operation, there was an evident need for a careful forecast of future regional traffic levels. The year 1975 was selected for this separate forecast, which consisted of a modified gravity-model origin-destination study, employing in general methods developed by Mr. Alan M. Vorhees of the Automotive Safety Foundation.

This model, after extensive testing at the 1954 level, was used for the separate prediction of commuter trips and trips made for other purposes on an average 1975 weekday. The Bay region was divided into cordon zones for each of which estimates of 1954 and 1975 population, jobs, labor force, and autos housed were prepared.

Each cordon zone's trip-generating capacity and attraction were related to these values. 1954 and 1975 travel times were estimated between each pair of zones and special curves of travel time distributive factors were developed, based on Bay Area experience.

The exact relationship between all elements of the model formula was arrived at after a series of adjustments. During this process the 1954 variables were used, the resulting trip estimates being compared with the 1954 O-D survey date. Once satisfactory results for 1954 were obtained, the variables for 1975 were inserted in the modified formula and the 1975 trip values were computed.

Because of the relatively recent development of this method of analysis, its use was tempered ultimately by reconciliation with a separate analysis. Rapid transit passenger volumes obtained by traffic assignments from the 1975 gravity model trip volumes were reconciled with a separate set of 1975-level rapid transit volumes. The latter had been assigned at the 1959 level from the updated existing O-D surveys and projected to the 1975 level by means of a comprehensive series of factors derived primarily from the statistical extra-polation of present trends.

Model traffic distribution, or diversion factors constituted a major area of research. There was an evident need for a more comprehensive basis than had previously been available for predicting the distribution between assumed highway and transit networks of total person-trips within a metropolitan area. The proposed bay area rapid transit system—because of its extent, speed, station-spacing, automatic operation, credit fare collection, and other

factors—lacks a counterpart among existing systems. As it is a prototype of forward-looking rapid transit concepts, it was appropriate to devote major study to the types and volumes of traffic which it might attract.

Research for rapid transit traffic diversion curves was concentrated in part in a bay area traffic corridor specially suited for such study, the Peninsula between San Francisco and San Jose. Here, existing relatively high-volume interurban passenger traffic uses Southern Pacific commuter trains, bus routes, and automobiles along the bayshore freeway.

The well-defined nature of the Peninsula traffic corridor, and the fact that its existing interurban transit facilities are the closest approximation in the bay area to the type of service which would be offered by rapid transit, made it especially valuable for study of the various factors which influence significantly modal travel relationships.

Data from the 1954 origin-destination survey, divided by time of day, purpose of trip, mode of travel, O-D pattern—and as to whether either or both trip terminals were in a major downtown area—were supplemented by data on travel time, cost, and distance for each mode of travel. Auto ownership, population density, and personal income data were also available.

It was therefore possible to analyze trips in great detail and variation and to search systematically for meaningful groupings of data. Various bases for diversion between travel modes were investigated, including time-ratio, time-differential, cost-ratio, cost-differential, time-cost-ratio, degree of auto ownership, and personal income levels.

A large number of diversion graphs resulted, but many could be rejected for one cause or another, such as having as a basis too few trips for statistical stability, general indications of poor correlation, or having inappropriate elements for their intended use.

From these intermediate studies, a number of time-ratio graphs were selected for further analysis, and these ultimately yielded a series of inverted Gompertz-type exponential curves, four for regional trips, and two for internal trips. These curves were then finalized in several stages, with consideration being given to trends in the development of traffic characteristics throughout the bay area.

In application, the four regional curves were used for peak-period, peak-direction work trips of interest, having one or both trip terminals in downtown San Francisco or Oakland; peak-period, peak-direction work trips of interest, with neither trip terminal in downtown San Francisco or Oakland; all other trips of interest, having either or both trip terminals in downtown San Francisco or Oakland, and all other trips of interest, having neither trip terminal in downtown San Francisco or Oakland.

The two internal traffic diversion curves apply to all trips of interest having either or both trip terminals in downtown San Francisco or Oakland; and all trips of interest having neither trip terminal in downtown San Francisco or Oakland.

Rapid transit patronage estimates were constructed upon the foundation of the O-D surveys, the diversion studies, and travel time-ratios. The latter were calculated for all interzonal movements of specific potential interest to rapid transit and based on the planned future regional highway and transit networks. Time-ratios were generally calculated both for peak and off-peak times of day and for movements between a relatively large number of zones.

The patronage estimates in their final form consisted of triangle tables showing the number of passenger trips on an annual weekday between each pair of stations of the proposed network. Several subsequent analyses tested the reasonableness of the estimates.

A separate study investigated the problem of fare structure. It was recognized that generally movements with definite potential for rapid transit utilization should have available out-of-pocket, per-person, door-to-door travel costs which are approximately comparable as between the automobile and rapid transit.

For this reason a thorough analysis of typical Bay Area auto travel costs was made, including the effects of auto occupancy, bridge tolls, parking fees, and the costs of gasoline, oil, and normal tire wear. The analysis also took cognizance of existing commute and cash transit fares in the area. The outcome of this study was the calculation of a unique fare based on route mileage, for each station-to-station rapid transit movement. Fare revenue was estimated from this table of fares and the triangle table of estimated rapid transit patronage. Advertising and concession revenue was estimated at one percent of fare revenue.

A rather exhaustive analysis of system operating methods and

results was undertaken. The system's many innovations, including its traffic characteristics, route configuration, station spacing, and rolling stock performance, militated against use of any existing system as a direct model for estimating the operating results of the SFBARTD system. Detailed train schedules for an entire annual average weekday's operation were prepared, to test track capacities, determine rolling stock and yard storage requirements, and, most important, provide data for the subsequent estimates of operating expense.

The latter was itself the subject of a thoroughly detailed examination in which Donald C. Hyde, General Manager, Cleveland Transit System, participated. His approval was obtained for the resulting operating expense estimates. Numerous tests of system performance were made, involving the previously-developed estimates of passenger trips, passenger-miles, fare levels, fare and concession revenue, train schedules, operating expense, car requirements, car use, and other factors.

It has been noted that the transportation and traffic studies were important both in configuring the system and in justifying its construction. The foregoing description of important features of these studies will indicate some of the information useful for such purposes. To understand more fully the basis for rapid transit, however, it is necessary to review salient aspects of the Bay Area economy as they affect its transportation requirements.

Present trends in the Bay Area are toward intensification and change of its metropolitan center functions and toward rapid growth in its dispersed lower-density outlying areas. Characteristically, population and labor force are declining slightly in the central cities, while economic activity and jobs continue to expand and become more specialized.

The economic interdependence between central business district and outlying area remains strong. Thus public policies which affect the economic growth of the regional center will affect the economic growth of the suburbs as well.

The headquarters-administrative, financial, professional, educational, and other specialized functions of downtown San Francisco, Oakland, and Berkeley are, taken together, the most important economic activity of the bay area. And during the last recorded

twelve-year period through 1958 San Francisco has moved up in national ranking of reported approximate central office space from fifth to third, while Los Angeles has moved down in rank from fourth to fifth.

Thus, as the District has pointed out, in spite of the continued outward relocation of factory facilities and jobs from San Francisco, the city is experiencing an annual net increase of more than 3,500 jobs. Because of the slightly declining population and labor force in San Francisco itself, all of this net job increase—and more—is being accounted for by suburban commuters traveling greater and greater average distances to and from work.

Consequently the person-miles involved in commuter and business trips, especially in peak periods, are expanding at a greater rate than would be indicated solely by population growth within the region. The increased average length of trip between home and work and apparent stable auto occupancy ratios in turn magnify the already heavy burdens placed on the bay region's available transportation facilities.

In particular, the problems of incapacity and congestion will become increasingly serious along the critical and lengthy high-volume corridors of regional travel, at the several water and hill gateway barriers, along planned new freeways in areas to be saturated by future traffic-generating urbanization, and at the terminal ramps, streets, and parking spaces of the central cities.

Thus perhaps the most important element of regional transportation need is the element for which rapid transit is specially suited: large concentrations of relatively long-length, peak period commuter trips. This evidence alone would appear to indicate an increasing need for rapid transit, especially when it is remembered that almost every large metropolitan area in the world has or is planning some form of rapid transit service.

It was desirable, however, to subject these indications of need to rigorous analytical tests. For example, at each major bay Area gateway created by land or water barriers, recent (1959) and estimated future (1975) peak-hour transit, highway, and total person-trip volumes were compiled. The 1975 values assumed rapid transit operation. In a series of gateway bar diagrams, these volumes were compared with existing and planned future highway capacities.

This analysis provided indications of actual recent and expected 1975 conditions along the major regional corridors and at the gateways.

Among these general indications were the following. Increasingly serious peak-period vehicular congestion can be expected, even with the planned future highway improvements, were rapid transit not to be constructed. As a result—and this cannot be too strongly emphasized—the economic, travel, and land use patterns of bay area development would become seriously warped to fit within the capacity limitations of an inadequate circulation network.

The bay area, of course, could function in some form without this complementary capacity, but it could not grow with the flexibility necessary to orderly and highly developed living and economic standards. The region would become Balkanized. Employers would find their labor supply range and quality effectively limited by commuting difficulties. Workers would similarly find their range of job choice restricted from a given homesite and their range of choice of residence restricted from a given jobsite. Mobility and flexibility—important to a high metropolitan growth standard in a specialized, technological era—would be compromised.

With the proposed regional rapid transit system complementing the planned freeway program, on the other hand, a major increase in overall transit patronage and substantial or complete elimination of major gateway vehicular congestion could be anticipated during the period of effective forecast. The heavy expenditure involved in certain major highway facilities, not now planned but soon to be required if rapid transit were not built, would be effectively forestalled or eliminated.

Two cases in point deserve particular mention. Both the bay and Golden Gate bridges have exceeded or are approaching their capacity limits. The future traffic demands in a region of twice its present population will be exceedingly severe. In both cases, rapid transit crossings of far greater passenger capacity can be constructed at considerably less than half the cost of second motor vehicle crossings, and can serve more effectively the major future desire lines of travel through these gateways.

Only rapid transit can economically penetrate to the hearts of

the central cores of regional activity in downtown San Francisco, Oakland, and Berkeley with a series of stations and without the space-consuming galaxy of additional ramps, approaches, interchanges, loading and parking facilities otherwise required.

According to the present progression of events, bay area citizens within the transit district will vote on the necessary bond issue sometime in 1962. If the required two-thirds vote is obtained, construction will commence soon afterwards.

The system will be opened in several separate phases, the first lines on this schedule beginning operation probably in 1967, and the entire first-stage system, described earlier, being opened by 1974. The challenge of the future, of preserving and enhancing our high American standard of living, is thus to be faced.

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